



PHD

Inflation Dynamics And Its Effects On Monetary Policy Rules

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Award date:
2015

Awarding institution:
University of Bath

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Inflation Dynamics And Its Effects On Monetary Policy Rules

by

Elvis Musango Moleka

A thesis submitted for the Degree of Doctor of Philosophy

in the subject of Economics

University of Bath

Department of Economics

October 2015

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Dedication

To my most loving parents: Mr Moleka Frederick. B & Mrs Moleka Regina. B

&

to my adorable brothers: Moleka Anslem. M, Dr. Moleka Marcus. O,

Barrister Moleka Collins. I, and Moleka Ebenezer. O.

Acknowledgements

A difficult task is to keep acknowledgements of those who have contributed toward the realisation of this research. This Ph.D. represents skills and knowledge gained over the course of my academic career. It is obvious that this thesis would not have been completed if not of the academic, moral, physical and financial support I have received from a number of people, to whom I express my sincere gratitude for their kind support and understanding.

I reserve all praises and glory to God Almighty who gave me the wisdom, grace, inspiration, strength, and protection throughout the course of this research. Father your word says in Philippians 1:6 that “every good work you began in us you will bring it to completion”. Thank you most gracious Lord.

My first pride goes to my research Supervisors: Dr. Bruce Morley, Dr. Nikolaos Sakkas and Dr. Ahmad Hassan Ahmad for their invaluable support in suggesting constructive feedback that went on to improve the quality of this thesis. I am indebted by the amount of time they devoted to correct my mistakes, by carefully reading multiple drafts of this thesis. This has enabled me to develop skills not only as a student, but also as a professional.

I reserve special thanks to the Graduate Research School (GRS) for University scholarship award and especially, to Catherine Adams (the former Postgraduate Research Administrator for Economics) for information and advice, when I first made an expression of interest to study for a Doctorate Degree. A huge thank you also goes to Michelle Hicks for her warm personality and kind encouragements.

I owe sincere gratitude to my parents and members of my family for assisting me financially and morally towards the realisation of this thesis, albeit they missed me while I was studying in the UK. I have had the support of my family since the early stages of my educational pathway. To start with my Father, Daddy thank you for examining my skills profile at an early stage of my academic career. When I first registered at the Undergraduate level to study Accounting and Finance, you

were quick to realized that I was excellent in Economics by having a Distinction in almost all modules, which made me to receive an Honours Degree in Economics. This later gave me a competitive advantage as I was then awarded a scholarship for my Masters Degree programme in Business Economics and Finance. Thank you for helping me made an informed decision.

Mum where can I start to thank you? If I had to express all of my gratitudes for you into writing, then it is worth doing another Ph.D. on this topic. Thank you for your constant prayer and your generous support in my decisions. Your knowledge as a business entrepreneur has taught me resilience, good time management and organisational skills. Mum this is for you:

*“A friendly and caring Mother,
with a God-fearing heart,
calm and always smiling.”*

Brother Anslem, I want to thank you for your kind encouragements throughout my study. I have learnt from your leadership qualities, especially developing strong interpersonal and communication skills which gave me the enthusiasm to complete this research. I also like to thank Dr. Moleka Marcus (MD), for been an exemplary role model to me. When I first studied Further Mathematics at the GCE Advanced Levels, I can recall Mr Njoh, who was then, the Tutor informing me that *“Moleka! your brother was usually the best student in Mathematics and Further Mathematics, by always scoring 100%”*. Thank you for helping me develop strong rigour in Mathematics and Quantitative analysis. When I think of the number of years it took you to be trained as a Medical Practitioner, it meant that spending 3 years doing my Ph.D. research was nothing as compared to yours. I am also grateful for the support by Barrister Moleka Collins and to Moleka Ebenezer. Your passion and encouragements motivated me to finishing this thesis.

I like to express my sincere gratitude to Elangwe Ndingi Besumbu Banamata for her enormous support during the writing-up stage of my thesis. I’m so grateful to have a wonderful person like you.

I would also like to thank members of the Economics Department at the University of Bath for academic and physical support. Your stimulating research-led environment in Economics and Econometrics applications enabled me to develop scholarly skills, as an independent researcher. This infused me with a more professional treatment in Applied Macroeconomics, with a particular emphasis on

inflation dynamics and monetary policy. I would like to say here, and in my opinion that:

*“The University of Bath
is one of the few universities,
where students have
studied with happiness”*

This comes as to no surprise why my experience in the University of Bath has been truly memorable and I have enjoyed teaching Financial Econometrics in the Department of Economics. I also express thanks to the Economics Ph.D. research students for professional discussions, and participating in interdisciplinary research training, which were mainly organised by the Researcher Development Unit at the University of Bath, foster my capacity for originality and constructive thinking.

I am also indebted to the University of Buea for providing me with rigorous training in Economics such as: Econometrics, Research Methods, Advanced Macroeconomics and Operations Research. Special thanks goes to Mr Mbu Sunday. A, my project Supervisor who advised me to undertake a terminal degree in Economics, after having obtained a Distinction (averaging 82%) on my final year research project.

Finally, I am grateful for the moral support given to me by Mr Andre Ngwai Ndi and his family, Mr Ngoh Ndumbe Mboka, Dr. Olalekan Bashir Aworinde, Mr Frederick Blavo, Mr Karthik Garikipudi and Mr Arbinder Singh throughout the course of this research. I am grateful for your kind support.

Elvis Musango Moleka

University of Bath

October 2015

Declaration

This thesis is entirely my own work and has not been submitted for a degree at another University. All references have been duly acknowledged.

Name:

Signed:

Date: October 2015

Abstract

This thesis examines dynamic relationships between inflation and monetary policy in a sample of African economies using quarterly data over the period 1980:01 to 2012:04. The literature on inflation dynamics and monetary policy focuses on developed economies, with little attention devoted to the African economies, which is potentially explained by the fact that in the past monetary policy played second fiddle because of fiscal policy dominance following episodes of high inflation and stabilisation policies that occurred in the 1980's. This thesis fills an important gap in assessing African's monetary policy.

The thesis predominantly uses the Vector-Autoregression (VAR) framework to examine the monetary policy frameworks of the African economies. The thesis finds that an interest rate shock on average explain a more significant proportion of the variance in the output gap and inflation than the exchange rate, in terms of analysing the decomposition of shocks to the economy. This shows a shift in the monetary policy focus away from exchange rate management to interest rate targeting as the African economies have become more market oriented. The monetary policy reveal strong asymmetric responses with respect to the macroeconomic variables when inflation exceeds its threshold value. The analysis suggests that monetary policy in the African economies is regime-dependent, propagated through the inflation thresholds, such that the authorities strongly implement policy changes when inflation goes beyond a certain threshold. The thesis reveals that by taking into account the prior belief of the monetary authorities, it helps produce better estimates of the performance of the monetary policy transmission mechanism, as it combines prior information with the sampling information which is contained in the data. The overall novelty of the thesis is that some African economies are adopting inflation targeting policies instead of exchange rate management. It is imperative that the subsequent inflation targeting frameworks will achieve monetary policy objectives for the African economies and the use of interest rate management should be continued.

JEL Classifications: B22, C11, C13, C15, C22, C32, C51, C53, E31, E32, E42, E47, E50, E52, E58 and F33.

Keywords: Inflation Dynamics, Monetary Policy, Shocks, Inflation Persistence, Structural Breaks, Transmission Mechanism, Exchange Rate, Inflation Thresholds, VARs, Structural Adjustment Programmes (SAP), African economies, Macroeconomic Policies, Economic Development.

Chapter 1

Introduction

1.1 Motivation and Contributions

There is a general consensus among economists that the main objective of macroeconomic policy is to achieve sustained economic growth in combination with low inflation. Africa's lack of economic growth (compared to the rest of the World) until recently has become an increasingly popular area of research, as attempts are made to determine why the performance has been below expectations which are price stability, exchange rate stability and real GDP growth. The strong reliance on primary commodities for growth generation has often led to them encountering negative supply shocks and the volatility in their exchange rates, due to instability in their currencies which has affected GDP growth. Monetary policy in the African economies, like many other developed economies has been conducted based on an eclectic approach which consisted of exchange rate monetary policy and inflation targeting frameworks. The fixed exchange rate mechanism was the most important exchange rate arrangements used beginning from the early 1960's until the early 1980's, to maintain stability of Africa's exports – mainly commodities. This was because Africa is a major source of raw materials to the rest of the World (Ikejiaku, 2008). The collapse of the fixed exchange rate mechanisms (Bretton Woods system) in 1973 across Africa led to alternative policy measures which were monetary targeting and SAP to stabilise the structure of the African economies as inflation soared above single digits, during the 1980's.

The monetary targeting policies which were implemented in the 1980's through to the early-to-mid 1990's were unsuccessful for the following reasons: The instability in the money demand function as a result of the debt crises meant that it was difficult to maintain a constant rate of growth of the money supply. This is because the African economies had relied on prudential macroeconomic policy

frameworks with fiscal policy dominance (Akinbobola, 2012; Mishra and Montiel, 2012). It is believed that the debt crises which accumulated through the International Monetary Fund's (IMF) and the World Bank's concessionary lending programmes had inflationary impacts on the African economies as they required higher interest rates on the repayments which increased the fiscal deficits (Caceres et al, 2013). Secondly, expanding financial markets across Africa made it difficult for the monetary authorities to control excess liquidity due to the increase in money supply given that the African economies have attracted higher capital inflows through aid allocation and investment in capital resources (Saxegaard, 2006). This coincided with the structural reform programmes which involved the liberalization of state-owned companies to expand domestic markets and encourage international competitiveness (IMF, 2014).

Prior to the 2000's, weak domestic policies caused by structural rigidities such as government intervention in the market economy and external disequilibrium involving the negative supply shocks led to low output growth. This was also due to limited central bank autonomy to independently conduct monetary policy. Growth in the early 2000's coincided with strong domestic policies and growth propelled by the Emerging market economies such as China, who were investing in Africa, having been attracted by the presence of their natural resources. The following effects have been observed. Firstly, inflation targeting frameworks have been introduced by the central banks of many African economies, with the aim of bringing down inflation to a single digit.¹ Secondly, the African economies are now transitioning toward market based instruments involving the use of the interest rate in conducting monetary policy. The debate as to whether the fiscal deficits to finance government expenditures were inflationary or whether inflation originated from depreciating exchange rates has led to different mechanisms for the appropriate response of monetary policy. In the past, fiscal policy dominance which required high debt servicing (by monetizing debts) led to high inflation. Recently, monetary policy has become an increasingly important macroeconomic framework in terms of stabilising the African economies. This thesis concentrates on the monetary conditions of the economy, as a potential area that could explain the levels of economic development and performance of the wider economy, due to the improvement in macroeconomic policies involving inflation targeting. The aim is to examine the appropriate policy responses of the monetary policy transmission mechanisms in order to investigate the effectiveness of the monetary policy instruments in maintaining macroeconomic stability.

¹However, high inflation still prevails in the African economies as compared to the developed economies.

Over the past few decades, a substantial amount of literature has been documented on the variants of inflation dynamics, which has attracted a wide scholarly debate and thus aroused interest among economic participants. Discussion about what causes fluctuations in economic activity often involves price dynamics in a combination with economic and monetary factors. Inflationary tendencies which emerged in the 1970's following the collapse of the Bretton Woods fixed exchange rate system influenced macroeconomic developments and institutional frameworks. In general, the period between the 1970's and 1980's was characterized by movements in the business cycle, driving changes in macroeconomic variables which mainly resulted from supply shocks (Canova and Ferroni, 2012). In recent years, economists generally believed that inflation targeting is the main objective of monetary policy due to inflation persistence and because inflation expectations strongly influence the behaviour of monetary policy. As a result, the role of monetary policy has gained increased attention among policy makers in terms of stabilising the economy. This is because inflation is often used as a signal to determine the credibility of monetary policy. It is often perceived that high inflation and low output growth may indicate inefficiency on the part of the central bank to stabilise the economy, particularly if inflation exceeds its threshold level. On the contrary, maintaining inflation within a monetary policy target, is often regarded as policy effectiveness and therefore gives credibility to central bank (Zhang, 2011; Meller and Nautz, 2012).

The main purpose of this research is to examine how the use of monetary policy to control inflation affects the wider economy in a sample of African economies where limited research has been conducted thus far and applying new econometric innovations with respect to the time-series approach. This aim is to determine the transmission mechanism of monetary policy shocks to the economy. The study of inflation dynamics is important for any economy whose monetary policy objectives are dependent on price stability. The research is interesting because studying inflation dynamics gives an understanding of how monetary policy responds to shocks and the adjustment process towards equilibrium (Kouretas and Wohar, 2012). Debrun et al (2010) and Mishra and Montiel (2012) pondered on how effective monetary policy is in low income countries. Conventional monetary policy has sought to explain the transmission mechanism of monetary policy shocks to the economy, the efficient inflation thresholds that maximises output growth as well as how to characterise monetary policy expectations and prior beliefs about shocks to macroeconomic variables. This is because monetary policy lacking credibility and asymmetric price adjustments could result in high inflation

and negative output gaps.

The literature suggests that monetary policy influences the fluctuations in output and inflation (Rafiq and Mallick, 2008). This has led to different empirical macroeconomic models and theoretical frameworks attempting to capturing inflation dynamics and the monetary policy framework. Studies focusing on structural change and the monetary policy framework include Zhang (2011), Aksoy and Piskorski (2006) and Zhang and Clovis (2009). These discusses whether monetary policy is responsible for the changes in inflation persistence and inflationary expectations. Clarida et al (2000) established that the conduct of monetary policy influences inflation expectations and changes to the macroeconomy, which was analysed by the use of the Taylor (1993) rule model, containing the output gap, inflation and the short-term interest rate, representing changes in monetary policy. Ascari and Ropele (2007) found that optimal monetary policy for the U.S economy depends on time-varying inflation² and therefore involves modelling a forward-looking monetary policy framework.

Studies which have produced evidence of low inflation persistence include. Cecchetti and Debelle (2006), argue that the positive decrease in the U.S inflation persistence over time was as a result of changes in the monetary policy framework and the business cycle. In a similar vein, Pivetta and Reis (2007) documented that there were no changes in inflation persistence for the U.S. Kumar and Okimoto (2007) estimated a time-varying model for the U.S inflation and found decline in inflation persistence, using the fractional integration approach. Amano (2007) argues that inflation inertia and persistence are found to be the most important factors affecting monetary policy due to the uncertainty in economic fluctuations. According to Benati (2008), irrespective of monetary policy effectiveness, inflation inertia and persistence remains a core issue, driving recent research in monetary macroeconomics. These studies have focused on a univariate model of inflation persistence. A more cogent approach used in this thesis involves capturing the persistence of inflation by modelling dynamic impulse response functions (IRF) of the monetary policy transmission mechanism that includes other macroeconomic variables which are important for the conduct of monetary policy.

Chowdhury et al (2006) established that the cost channel was influencing monetary policy and inflation dynamics for more open economies and used the New Keynesian Model (NKM). A rather controversial aspect of the literature is

²This is defined as the change in the mean of inflation over time.

measuring inflation persistence. Mishkin (2007a) assumed that inflation persistence is measured by summing up the coefficients for the lagged inflation and examining if it adds to one. This is the most commonly used method in the literature to model inflation persistence. Whereas, O'Reilly and Whelan (2005) argue that backward-looking inflation is inconsistent with the era of inflation targeting (where the central bank commits to reduce inflation to a target level). Gali and Gertler (1999) estimated a backward-looking model of inflation and found that lagged inflation was responsible for the persistence of inflation. Therefore, there exists mixed evidence on whether lagged or expected inflation matters for measuring inflation persistence.

Following its introduction by Sims (1980), the VAR model and its variants has been introduced into monetary policy analysis in order to study economic relationships between macroeconomic variables. The use of the Structural VAR (SVAR) for monetary policy and inflation dynamics include work by Christiano et al, (1996, 1999) using contemporaneous short-run restrictions, Blanchard and Quah (1989) (BQ) using a long-run identification scheme and sign restrictions by Uhlig (2005) and Fry and Pagan (2011). Most studies use the zero restrictions instead of the sign restrictions in analysing monetary policy due to their advantages in capturing the true effects of structural shocks to the economy.

Studies on the threshold VAR (TVAR) model include work by Tsay (1989, 2005), Hansen (1996, 2000), Balke and Wohar (1998), Weise (1999), Balke (2000), Altissimo and Violante (2001), Khan and Senhadji (2001), Taylor (2001), Atanasova (2003), Frimpong and Oteng-Abayie (2010), Catik and Martin (2012), Mandler (2012) and Phiri (2012) to determine efficient optimal levels of the inflation rate, interest rate and exchange rate beyond which these variables affect monetary policy framework when they exceed their threshold levels. More recently, the Bayesian VAR (BVAR) approach has gained renewed interest in the literature in order to explore changes in the economy. Among the most often cited studies in the empirical literature there is: Litterman (1984, 1986), Kadiyala and Karlsson (1997), Robertson and Tallman (1999), Ciccarelli and Rebucci (2003), Giannone and Reichlin (2006), De Mol et al (2008), Koop (2010), Koop and Korobilis (2010) and Banbura et al (2010).

The application of these methods in the context of the African economies has been limited so far, which underpins the main motivation of this research. The empirical contributions of the thesis to the literature includes it determining structural breaks consistent with an evolution in monetary policy, investigating of

the transmission mechanism of monetary policy shocks to the economy, examining the asymmetric effects of monetary policy shocks which are caused by inflation threshold regimes and lastly, to explore the performance of the monetary policy transmission mechanism in a selection of African economies.

1.2 Aims and Objectives

There are six main objectives behind this thesis. In order to capture movements in the business cycles and inflationary trends, the thesis uses quarterly data over the period 1980:01 to 2012:04 for a sample of African economies as compared to the more commonly used annual data which has limited observations. The aim is to provide a wider spectrum to analyse the transmission mechanism of monetary policy shocks as well as to capture the transition (which is otherwise known as turbulent) periods in monetary policy. This was characterized by SAP and changes in macroeconomic reforms for the majority of the African economies, although the experiences in these countries are not homogeneous. The second aim of this thesis is to provide an overview of the exchange rate and monetary policy frameworks of the African economies. This is to understand their policy background as to the evolution of monetary policy tailored toward inflation targeting and output growth as the African economies have become more market oriented.

Regarding the analytical framework, the third objective is to identify structural breaks in macroeconomic variables using the Lee and Strazicich (2003) (LS) Lagrange Multiplier (LM) two minimum break point test. The advantage of the LS test over the Bai and Perron (2003) test is that it considers both unit root and structural breaks, whereas the latter test accounts only for structural breaks in the data. The structural breaks are endogenously determined, therefore reducing the effect of spurious biases when the break dates are determined exogenously. The fourth aim of the thesis is to assess the effectiveness of monetary policy shocks in the African economies. The study uses IRF and forecast error variance decompositions (FEVD) to analyse the transmission mechanism of monetary policy shocks based on the theoretical framework underlying the structure of the economy. This is based on the New Keynesian approach, where it is assumed that shocks are the dynamic effects of aggregate supply, aggregate demand, money supply, money demand, commodity price and exchange rate shocks.

The fifth aim of the thesis is to examine the impact of non-linearity in the inflation rate on monetary policy. Here, we consider departures from symmetric relationships in monetary policy and assume non-linear specifications propagated

by inflation thresholds. This approach has an advantage in that the optimal inflation thresholds are endogenously determined along with the asymmetric effects of monetary policy shocks. Lastly, the sixth aim of the thesis is to explore the performance of the monetary policy transmission mechanism in the sample of African economies, using the BVAR approach.

1.3 Structure of the Thesis

The remainder of the thesis proceeds as follows. Following the introduction, Chapter 2 discusses the literature on inflation dynamics. The chapter reviews the most relevant literature on inflation dynamics by examining differences in methods used, data and empirical assumptions. The aim is to provide a rationalization of the theoretical literature and to shed light on understanding on empirical evidence on inflation dynamics and monetary policy. Chapter 3 focuses on the policy background of the selected African economies on which the research design is based. The chapter addresses the exchange rate policy, including SAP and stabilization measures as well as the evolution of the monetary policy framework. Chapter 4 presents data and testing for stationarity by analysing the time-series properties of the variables. The chapter offers a contribution in modelling structural breaks within unit root tests with respect to monetary policy. Structural break points were endogenously determined from the data. This is to eliminate bias that may rise in an attempt to exogenously determine the break dates.

Chapter 5 assesses the effectiveness of monetary policy on the sample of African economies. The chapter provides a detailed analysis of the VAR, the identification strategy and quantifies the effectiveness of monetary shocks to the real economy. In Chapter 6, the non-linearity between inflation and monetary policy is examined, where inflation regimes are endogenously determined. Chapter 7 explores the performance of the monetary policy transmission mechanism in the African economies. The contribution of the chapter is to analyse how monetary policy changed its behaviour in response to changes in information from a set of macroeconomic variables. Finally, chapter 8 concludes on this thesis. This includes a summary of the major findings, policy implications and recommendations for further research.

Chapter 2

Literature Review on Inflation Dynamics

2.1 Introduction

Most of the literature on inflation dynamics and monetary policy has centred on the modelling aspect, with fewer papers aiming to provide a rationalization of the theoretical framework. This is perhaps due to the controversy that exists in the literature in terms of modelling the indicators of inflation and how monetary policy responds to inflation persistence and inflation expectations.¹ Over the past few decades, the NKM has provided the benchmark from which most studies on inflation dynamics have been analysed. The NKM is based on the principle of rational expectations by economic agents, where expectations are formed based on all available information. NKM rests on the assumption that aggregate inflation, given uncertainty in the degree of inflation persistence consists of a backward-looking component, from which prices are indexed and a forward-looking component from which expectations are derived (Woodford, 2003). A paramount example is the study of Clarida et al (2000) who model monetary policy reaction functions with respect to the expected inflation and the output gap. The output gap is defined as the proportional difference between actual output and the potential or equilibrium level of output.

This chapter examines the literature review on inflation dynamics. The aim is to understand current trends and gaps in the literature. This review attempts to identify differences in results which may have been brought about by differing estimation methods, variability in the sample size and the assumptions about the data. The outline of the chapter proceeds as follows. Following the introduction,

¹The theorizing of inflation expectations, emanates from the pioneering work of Friedman (1968) and Lucas' (1972) rational expectations model.

section 2.2 introduces the theoretical literature of inflation dynamics as well as empirical evidence which is discussed in section 2.3. Section 2.4 is a summary analysis of the literature review showing table of studies. Lastly, section 2.5 is the conclusion.

2.2 Review of the Theoretical Literature on Inflation Dynamics

In this section, we discuss inflation persistence and optimal monetary policy. This is to ascertain how uncertainty affects the conduct of the monetary policy framework regarding the optimizing behaviour of economic agents. The methods of measuring inflation persistence is documented as well as the Taylor (1993) rule for measuring changes in the monetary policy reaction function. The section also considers the identification and decomposition of the SVAR approach as well as the theoretical model which underscores the TVAR approach for the monetary policy framework.

2.2.1 Theoretical Literature

Amano (2007) analysed the relationship between inflation persistence and monetary policy using the NKM (depicted in equation 2.1 below). This aimed to provide an explanation of monetary policy with regard to uncertain variability of inflation inertia.² This is defined as changes in inflation resulting from structural persistence. Let π_t denote inflation gap (which is the deviation between inflation and the inflation target) at the current period while y_t denotes the corresponding level of the output gap. According to Amano (2007), given inflation persistence, the baseline model can be stated as follows.

$$\pi_t - \rho\pi_{t-1} = \lambda E_t(\pi_{t+1} - \rho\pi_t) + \alpha y_t + s_t \quad (2.1)$$

The parameters λ and α represent the coefficient of expected inflation and the coefficient of output gap on current inflation. $s_t \sim i.i.d(0, \sigma^2)$ denotes a supply-shock (cost-push), arising from the assumption of the model relating to the Phillips curve. This implies an analysis of inflation from the supply-side of the economy. The intuition behind equation (2.1) is that the degree of inflation persistent parameter, ρ with $0 \leq \rho \leq 1$ depends on the effect of the last period's aggregate price index (backward-looking), while expected inflation, $E_t(\pi_{t+1})$, is

²Walsh (2005) and Amano (2007) stressed that accounting for inflation persistence, reduces the variability of inflation.

forward-looking, respectively. Consider two scenarios; if $\rho = 0$ and $\rho = 1$ in equation (2.1).

$$\pi_t = \lambda E_t(\pi_{t+1}) + \alpha y_t + s_t \quad (2.2)$$

$$\pi_t - \pi_{t-1} = \Delta\pi_t = \lambda E_t(\pi_{t+1} - \pi_t) + \alpha y_t + s_t \quad (2.3)$$

The effect of assuming no persistence in inflation in equation (2.1) gives equation (2.2), with the implication that current inflation depends on expected future inflation and the output gap with a supply shock. The condition under which this will hold depends on the effectiveness with which monetary policy controls inertia, in terms of inflationary expectations. If the level of inflation persistence is perfectly unitary, the left hand side of equation (2.3) becomes a difference equation (first difference of the inflation gap). Where $\Delta\pi_t = \pi_t - \rho\pi_{t-1}$ represents the “quasi difference” of the true inflation rate (understood by the monetary policy). Modelling equation (2.3) would mean testing for stationarity in the inflation series by assuming that prices are $I(1)$ and inflation $I(0)$.³ Amano (2007) pinpointed that equation (2.1) provides the baseline model from which monetary policy would react.⁴ Taking fitted values for the inflation persistence parameter, from equation (2.1) gives.

$$\pi_t - \hat{\rho}\pi_{t-1} = \lambda E_t(\pi_{t+1} - \hat{\rho}\pi_t) + \alpha y_t + s_t. \quad (2.4)$$

Similarly, $0 \leq \hat{\rho} \leq 1$, while $\Delta\hat{\pi}_t = \pi_t - \hat{\rho}\pi_{t-1}$, denote the quasi difference of perceived inflation. We assume $\psi = \hat{\rho} - \rho$, represents the degree of misperception of the true effect of inflation persistence (which is the level of perceived inflation) to the central bank. It is important to understand how monetary policy reacts from these theoretical postulations. Three points stand out clearly; firstly, if $\psi = 0 \iff \hat{\rho} = \rho$ it means that monetary policy incorporates an exact (accurate) estimation of the persistence parameter and thus fully captures inflation inertia. In this case, perceived inflation is equal to the actual level of inflation persistence. Secondly, if $\psi < 0 \iff \hat{\rho} < \rho$, monetary policy is underestimating the true effect of inflation inertia. Finally, if $\psi > 0 \iff \hat{\rho} > \rho$, indicates that monetary policy is overestimating the true degree of inflation inertia. Therefore, getting a balance between monetary policy estimates and the true degree of inflation persistence remains a challenge for most central banks.

³Where I is the order of integration. This is defined as the number of times in which inflation is differenced to achieve stationarity.

⁴Notice that equation (2.1) does not include an interest rate variable (as in the Taylor-rule) equation, showing that monetary policy reacts differently to shocks in inflation and that different models affect monetary policy behaviour differently.

2.2.2 Optimal Monetary Policy Under Discretion

In another perspective, Amano (2007) considered a case of optimal monetary policy under discretion. This means that private expectations are taken as given, by the central bank as it cannot influence future expected inflation.⁵ In this case, the central bank considers the output gap as the policy instrument to influence inflation and the level of inflation persistence. This gives a static solution as:

$$y_t = -\lambda[\pi_t - \hat{\rho}\pi_{t-1}] \quad (2.5)$$

where y_t measures the output gap as in equation (2.1) and $\lambda = \frac{\alpha}{\beta}$.⁶ But it is estimated that $\psi = \hat{\rho} - \rho \iff \hat{\rho} = \rho + \psi$. Substituting this into equation (2.5), one can established the following trade-off between the output gap and inflation.

$$y_t = -\lambda[\pi_t - (\rho + \psi)\pi_{t-1}] \quad (2.6)$$

Equation (2.6) suggests a non-linear function between the output gap and inflation.

A third dimension to analysing the problem of inflation persistence and monetary policy is to assume that the perceived inflation equals zero, irrespective of the true degree of inflation inertia (if $\hat{\rho} = 0 \iff \psi = -\rho$). The effect of this in equation (2.2) is:

$$\pi_t = -\rho E_t(\pi_{t+1}) + \alpha y_t + s_t \quad (2.7)$$

Note that the degree of inflation expectations is $\lambda = \psi = -\rho$. Equation (2.7) suggest that inflation variability reduces if monetary policy targets output (large α) more than the change in inflation persistence (ρ).

This follows the same reasoning as can be found in the Taylor Rule equation: $i_t = \bar{r} + \pi_{t+1}^e + h(\pi_t - \pi^*) + b(y_t - \bar{y})$. If the central bank focuses on stabilizing output, then, the parameter $h < b$ and the reverse is true if inflation is targeted more than output stabilization. Having conducted an extended analysis of

⁵In particular, developing economies where the expectation channel of the monetary transmission mechanism is weak (Davoodi et al, 2013).

⁶where β is the coefficient of the output gap from the loss function, $L_f = \frac{1}{2}(\Delta\hat{\pi}_t^2 + \beta y_t^2)$, subject to the constraint, $\Delta\hat{\pi}_{t+1} = E_t\Delta\hat{\pi}_{t+1} + \alpha y_t + s_t$. This follows Clarida et al (1999) proposition of “leaning-against the wind” policy. This is defined as a countercyclical monetary policy, where the central bank raises the interest rate beyond the level required to maintain price stability due to fears of inflationary expectations and financial imbalances, such as the asset price bubbles (Svensson, 2014).

inflation persistence, the main policy conclusion is for monetary policy to underestimate inflation persistence ($\hat{\rho} < \rho$), when subjected to uncertainty in the level of inflation inertia. The assumption is that inflation is white-noise irrespective of its true persistence.⁷

2.2.3 Measuring Inflation Persistence

A second theoretical debate in the literature is on measuring inflation persistence. The question which concerns most authors is whether inflation persistence could be measured by the lagged inflation. Mishkin (2007a) argued that inflation persistence is measured by summing up the coefficients for the lagged dependent variables (backward-looking) and examining if it adds to one, expressed as follows.

$$\pi_t = \beta + \beta_1\pi_{t-1} + \cdots + \beta_p\pi_{t-p} + \varepsilon_t \quad (2.8)$$

Where the Akaike (1974) information criterion (AIC) is used to determine the lag length p . Equation (2.8) requires a simple autoregressive process of inflation with its lags and if the sum equals unity, indicates high levels of inflation persistence. Hansen (1999a) proposed a grid bootstrap method for confidence interval construction, which is used to test the significance of the coefficients about the persistence of the inflation variable.⁸

O'Reilly and Whelan (2005) provided a theoretical critique of backward-looking rational expectations models of inflation persistence. The theory implies that inflation persistence (measured in terms of lagged inflation) should decline as the central bank commits to target inflation. The theory centres on the reduced-form Phillips curve model of the form.

$$\pi_t = \dot{\beta} + \rho\pi_{t-1} + \sum_{k=1}^p \phi_k\pi_{t-k} + \delta\eta_t + \varepsilon_t \quad (2.9)$$

Where η_t represents an array (vector) of other variables (such as the output gap, interest rate, marginal costs) which affect inflation, while the persistence parameter is measured by ρ and $\dot{\beta}$ represents the monetary policy target of inflation as a constant. Shocks to inflation are denoted by ε_t .

⁷Walsh (2010) concluded similarly on optimal monetary analysis when the central bank is faced with uncertain variability on the level of inflation inertia. One reason to suggest this is an assumed welfare-theoretic central bank loss function by the central bank (Woodford, 2003). It can be inferred that inflation uncertainty affects the conduct of monetary policy.

⁸See Benati (2008) for similar application of measuring the inflation persistence, using the Hansen (1999a) approach.

According to O'Reilly and Whelan (2005), the main critique of the specification in equation (2.9) is the assumption of backward-looking inflation, which becomes implausible with a rolling or time-varying mean. They suggest the model fails to address inflation persistence if the central bank allows its target to drift over time. This can be shown by allowing lagged inflation to equal zero, from equation (2.9).

$$\rho\pi_{t-1} + \sum_{k=1}^p \phi_k \pi_{t-k} = 0 \iff \pi_t = \dot{\beta} + \delta\eta_t + \varepsilon_t \quad (2.10)$$

Equation (2.10) is the reduced form model of equation (2.9), showing that lagged inflation terms equal zero when monetary policy is forward-looking. However, without inflation targeting by the central bank, equation (2.9) applies. The summary conclusion drawn from this theoretical insight is that backward-looking inflation is inconsistent in the phase of inflation targeting but it is relevant in explaining inflation persistence.

Gali and Gertler (1999) estimate a backward-looking model of inflation and contrasted it with a forward-looking model. They measured inflation by the percentage change in the GDP deflator, and the output gap, using real marginal cost (mc_t). Their approach is drawn from the fact that backward looking inflation explains inflation persistence, as a result of the slow adjustment of marginal cost to movements in the output gap. This can be written as follows:

$$mc_t = \beta y_t \quad (2.11)$$

where y_t is the output gap represented as; $(y_t - \bar{y})$ and β is the output gap elasticity of marginal cost in the current period. Gali and Gertler (1999) argue that price stickiness may be captured by the real marginal cost (as an alternative measure for the GDP) in explaining output and inflation dynamics.

2.2.4 Monetary Policy Rule and Interest Rate Smoothing

The effects of changes in monetary policy on inflation dynamics have been addressed in a study by Clarida et al (2000). The first strand of their argument was to model a forward-looking component for expected future inflation $E(\pi_{t+k})$ and the expected future output gap $E(y_{t+q})$ based on the information set, (Ω_t) . The subscripts; π_{t+k} denotes change in the price level between the current period t and $t + k$, while y_{t+q} denotes the change in the output gap between period t and period $t + q$. This means, estimating a Taylor (1993) equation for monetary policy in which the central bank sets the nominal interest rate at a given time

period which is denoted as i_t^* in order to influence the real interest rate (\bar{r}_t). The nominal interest rate, depends on the output gap and inflation represented by y_t and π_t respectively.⁹ The baseline model for the monetary policy reaction function is specified as follows.

$$i_t^* = \bar{i} + \lambda(E[\pi_{t+k} - \pi^*] + \delta E[y_{t+q}]) \quad (2.12)$$

The model assumes a forward-looking component for both inflation and the output gap at different horizons. λ and δ measures the slopes of inflation and the output gap. In other words, they have an important bearing on the conduct of monetary policy with respect to shocks in inflation and the output gap. \bar{i} is an estimated desired nominal interest rate, which is observable when both inflation and output are targeted (Carlin and Soskice, 2006).

The second strand of their analysis addresses the pitfalls of the baseline model (2.12) by introducing the effect of the real interest rate. This is because equation (2.12) assumes that monetary policy responds solely on the basis of targeting nominal interest rate with respect to the desired level of expected inflation and the output gap. The nominal interest rate depend on the real interest rate and expected inflation. That is $i_t = \bar{r}_t + \pi_{t+1}^e \iff \bar{r}_t = i_t - \pi_{t+1}^e$. Introducing the concept of rational expectations (where it is assumed that agents will not make unsystematic errors, given the set of information available), then, the real interest rate (ignoring subscripts) is defined below.

$$\bar{r} = \bar{i} - \pi^* \iff \bar{i} = \bar{r} + \pi^*$$

The long-run equilibrium level of interest rate is given as the difference between the targeted level of the real interest rate less the inflation target. That is, $\bar{r} = r^* - \pi^*$. The model with the addition of real interest rate becomes after arranging terms the following:

$$\begin{aligned} r_t &= \bar{r} + (\lambda - 1)E[\pi_{t+k} - \pi^*] + \delta E[y_{t+q}] \\ (r_t - \bar{r}) &= (\lambda - 1)E[\pi_{t+k} - \pi^*] + \delta E[y_{t+q}] \end{aligned} \quad (2.13)$$

where $(r_t - \bar{r})$ from equation (2.13) is the real interest rate gap. This is the proportional difference between the real interest rate and the long-run equilibrium level of the real interest rate. Equation (2.13) imposes various implications for monetary policy. First, inflation shocks are persistent, if the sensitivity of the

⁹Where $y_t = y_t - \bar{y}$; is the output gap and $\pi_t = \pi_t - \pi^*$, π^* equals the inflation target by the central bank. Inflation is defined as the annual percentage change in the price level.

expected inflation gap is below or equal to unit ($\lambda \leq 1$) and the sensitivity of the output gap is less than zero; $\delta \leq 0$. The tightening of monetary policy (through higher interest rate) is optimal if $\lambda > 1$ and $\delta > 0$.

2.3.4.1 Introducing Interest Rate Smoothing

Interest rate smoothing underpinned the third strand of this theoretical framework developed by Clarida et al (2000). This stemmed from the limitations of equation (2.12), which includes the failure to account for dynamism in the central bank reaction functions by smoothing changes in interest rate. Secondly, it assumes an immediate response of the target nominal interest rate to the output gap and inflation. Thirdly monetary policy has perfect insights in controlling the desired interest rate, with respect to the targeted level of interest rate. Allowing for interest rate smoothing gives:

$$i_t = \phi i_{t-i} + (1 - \phi) i_t^* \quad (2.14)$$

where i_t^* is the forward looking targeted nominal interest rate set by the monetary policy authorities and given by equation (2.12) above. ϕ measures changes in the interest rate, while $(1 - \phi)$ measures the efficiency with which the central bank accounts for deviations in its current target. The monetary policy reaction function is obtained by combining equations (2.12) and (2.14).

$$i_t = (1 - \phi) [\bar{i} + \lambda(E[\pi_{t+k} - \pi^*] + \delta E[y_{t+q}]) + \phi i_{t-i} \quad (2.15)$$

The policy reaction function is estimated using either instrumental variables (IV) or the Generalized Method of Moments (GMM) for estimating the monetary policy. One repercussion is that estimating the model using the OLS technique could produce biased coefficients for inflation and the output gap. The recommended choice is to use the GMM.

2.2.5 Identification of the SVAR Models

In contrast to measuring inflation persistence by the lagged inflation and the effect of changes in interest rate on monetary policy reaction functions, this section reviews evidence relating to the identification of structural shocks to the economy. These identification schemes include: the long-run, the short-run and the sign restrictions, which are often cited in the literature to decompose the structure of the economy. The long-run restriction was motivated by BQ who argued that demand shocks have no long-run impact on deviations in output. Using a

bi-variate model, BQ assumed that demand shocks have a transitory impact on the output gap, by restricting only one long-run coefficient. One criticism with the BQ model is that it does not provide enough restrictions for capturing the dynamic effects of shocks and thus the level of persistence in the economy. The economy cannot be characterized by only two shocks, as external shocks play an important role in the monetary policy framework and inflation dynamics (Buckle et al, 2007). In an earlier paper, Gali (1992) applies a structural identification to establish the relationship between the money and product market equilibrium and monetary policy using both short and long-run restrictions.

Unlike identification achieved via long-run restrictions, Christiano et al (1996, 1999) proposed a short-run identification scheme. Their approach assumes that the matrix of endogenous variables, denoted z_t can be partitioned into two groups following the Cholesky criteria and based on ordering of the variables as; $z_t = [z_{1t}, i_t, z_{2t}]'$, where z_{1t} denotes variables such as the output gap, inflation, a commodity price index, i_t represents short-term nominal interest rate and z_{2t} denotes a set of conditioning variables which includes total and non-borrowed reserves. This recursive identification has been criticised based on its assumption that variables do not contemporaneously affect each other and lower triangularity does not consider theoretical justifications for identifying shocks, unlike the non-recursive identification scheme¹⁰ (Lutkepohl, 2005).

Fry and Pagan (2009) impose sign restrictions on the vector of impulse responses for a small open macroeconomic model, consisting of the output gap (y_t), inflation (π_t) and the policy interest rate (i_t) to ensure that monetary policy had a positive impact on inflation and the output gap. Statistically, this implies a reduction in the output gap, a fall in inflation and an increase in the interest rate following the shock from monetary policy.

$$\begin{bmatrix} y_t \\ \pi_t \\ i_t \end{bmatrix} = \begin{bmatrix} + & - & - \\ + & + & - \\ + & + & + \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{\pi t} \\ \varepsilon_{it} \end{bmatrix} \quad (2.16)$$

Where, ε_{yt} , $\varepsilon_{\pi t}$ and ε_{it} are shocks to the output gap, inflation and the interest rate equations respectively. It is often found that a contractionary monetary policy will increase the short-term interest rate (which has a direct impact on consumption and investment spending) and thereby reduces aggregate demand.

Using a similar analogy, Uhlig (2005) analysed the response of monetary pol-

¹⁰Also see Kim (1999), Sousa and Zaghini (2007) for non-recursive identifying restrictions.

icy shocks to macroeconomic variables for the U.S economy (including monetary aggregates of non-borrowed money and total reserves as in Christiano et al, 1996). The main argument is that identification achieved through normalization could not fully recover structural equations from the reduced form model if the underlying composition of the economy is unknown. This is often the case with Bayesian techniques where prior distributions are formed (Uhlig, 2005; Fry and Pagan, 2011). Demiralp and Hoover (2008) have used bootstrap methods for identifying macroeconomic shocks, based on the signs of IRF. The implication of different identification shows that SVARs are sensitive to the identification strategy about the information sets on the economy.

2.2.6 The Threshold Autoregressive Model

Another strand of the literature considers the threshold autoregressive (TAR) model, which is used to determine efficient optimal levels beyond which macroeconomic variables affect the conduct of monetary policy. The uncertainty surrounding monetary policy regarding expectations in inflation has attracted interest in recent years and led to the consideration of alternative non-linear tests, such as the Hansen (1996) test when the nuisance parameter is undefined. The statistical question is whether or not one can reject linearity in favour of a non-linear alternative model (Hansen, 1999b). To address this issue, the review of the theoretical literature considers the formulation of the TAR model and optimal lag order in a TAR framework.

2.3.6.1 Specification of the TAR Model

Despite the non-agreement that exists in the literature in terms of identifying the threshold variable, which is often dependent on the rationale of the study, there is a general form of specifying the model, following the pioneering works of Tong and Lim (1980), Tong (1983), Tsay (1989), Franses and van Dijk (2000), Tsay (2005) and more recently, Enders (2010). To express this idea in practice, consider the univariate time-series variable y_t which takes the following form:

$$y_t = \beta_1 + \sum_{i=1}^m \alpha_i^1 y_{t-i} + I_t(q_t - d > r) \left[\beta_2 + \sum_{i=1}^k \alpha_i^2 y_{t-i} \right] + \varepsilon_t \quad (2.17)$$

where, β_1 and β_2 are the constant parameters, q_t is the threshold variable, d is the delay lag, r is the threshold value and ε_t is the residual disturbance assuming no serial correlation. α_i^1 and α_i^2 represent the coefficient terms which differ across regimes in the presence of a threshold effect. The theoretical framework assumes that the non-trivial thresholds, r_i , $i = 1, 2 \dots j$ serve as change points of

the threshold variable relative to the delay lag. Regime changes occur depending on the value of r . The terms m and k are the autoregressive lags for regime 1 if the indicator function $I_t(.) = 0 \iff q_t \leq r$ and one otherwise for regime 2, where $q_t > r$ respectively. One may suggest that the purpose of the indicator function is to facilitate regime-switching, depending on the states of the economy. The Wald statistics, initially proposed by Davies (1987) have been used to test for the presence of non-linear effects against the null hypothesis ($H_0 : \beta_1 = \beta_2 = 0$) of linearity that the coefficients of the model are equal across the sub-samples or different states of the economy.

2.3.6.2 Choice of the Optimal Lag Length Selection

The literature suggests that the optimal lag length is relevant in determining the threshold parameter as well as the number of regimes. Pitarakis (2006) developed a test to measure the presence of threshold effects and obtain lag lengths from linear and non-linear models. Consider the basic threshold model in equation (2.17) where, q_{t-d} is the threshold variable, causing a change in regime. Under linearity, the lag length is estimated from a linear regression of the form:

$$y_t = \beta + \alpha_1 y_{t-1} + \dots + \alpha_p y_{t-p} + \varepsilon_t \quad (2.18)$$

where, $p \in (1, p_{\max})$ is the autoregressive lag length. Given a penalty term denoted as Γ , the model selection requires that:

$$IC(p) = \log \left(\sum_{t=1}^T (\hat{\varepsilon}_t^2) / T \right) + \frac{\Gamma}{T} (p + 1) \quad (2.19)$$

where, $\hat{\sigma}^2 = \sum_{t=1}^T (\hat{\varepsilon}_t^2) / T$ is the residual variance. From equation (2.19), the information criterion is determined by the residual variance of the estimated linear model, with respect to the penalty term. By implication, the lag length estimator is defined as: $\hat{p} = \arg \min_{1 \leq p \leq p_{\max}} IC(p)$.

Alternatively, under the assumption of threshold non-linearity, model selection takes the following form:

$$IC(p, d, r) = \log(\hat{\sigma}^2(p, d, r)) + \frac{\Gamma}{T} (2p + 2) \quad (2.20)$$

where, $\hat{\sigma}^2$ has been defined above. The optimal model for the non-linear alternative is selected by minimising the information criterion:

$$\min pIC(p) < \min_{p, d, r} IC(p, d, r)$$

with $1 \leq p \leq p_{\max}$, $d \leq p$ and $r \in \Gamma^*$. It emerges that under the assumption of non-linearity, the information criteria is dependent on the autoregressive lag (p), the delayed parameter (d) as well as the number of regimes (r), in contrast to linearity where the optimal lag length depends only on p . Based on simulations, Pitarakis (2006) concludes that the AIC is the most adequate information criterion when specifying a linear autoregressive model for the purpose of testing the model against a self-exciting autoregressive (SETAR) alternative. By definition, this implies that the dynamics of the threshold variable, q_t are determined by their own lagged value, relative to the delay parameter d and when the threshold variable constitutes an endogenous variable in the VAR model. SETAR is estimated by sequential (conditional) least squares methods (Hansen, 1996, 2000).

2.3 Empirical Studies on Inflation Dynamics

The main objective of this section is to review empirical studies on inflation dynamics and monetary policy which are consistent with the underpinnings of the theoretical literature.

2.3.1 Inflation targeting and Interest Rate Smoothing

Clarida et al (2000) examine the impact of inflation dynamics on changes in monetary policy rules in the U.S for the period 1960 to 1996. Quarterly time-series data for the U.S. Federal funds rate, inflation measured by the consumer price index (CPI) and GDP deflator and the output gap were obtained from CITIBASE. Output gap¹¹ measure was proxy by the Congressional Budget Office. Interest rate was assumed to be stationary because the presence of a unit root would imply time-varying trend in monetary policy.

Using the GMM, inflation target was estimated as, $\pi^* = 4.23$ for the pre-Volcker period (1960:1 to 1979:2) and $\pi^* = 3.58$ for the period 1979:3 to 1996:4. The degree of inflation persistence parameter were estimated $\lambda = 0.83$ and $\lambda = 2.15$ for the first and second periods respectively. Policy implication suggests that accommodative monetary policy caused volatility and persistence in inflation shocks in the pre-1979 era. One mechanism is to assume that the central bank lowered short-run nominal interest rate, which had a positive effect on aggregate demand but a negative impact on inflation. This means that prices rose more than the increase in the Federal funds nominal interest rate. On the contrary, restrictive monetary policy in the period after 1979 lowered inflation

¹¹Detrended, using the Hodrick-Prescott (1997) (HP) filter.

expectations because the Fed increased the short-term interest rate, to reflect changes in inflation. These results are consistent with the theoretical explanations on interest rate smoothing by the central bank.

2.3.2 Review of Inflation Persistence and Structural Change

In an empirical framework, O'Reilly and Whelan (2005) analyse Euro inflation, using quarterly data for the period 1970:1 to 2002:4. Inflation was measured by the GDP deflator and the harmonized index of consumer prices (HICP). Results from the Hansen (1999a) grid bootstrap technique (assuming $\rho = 50\%$, a median unbiased estimate) produced an estimate of the GDP deflator of 1.022 and 1.025 for the HICP, showing that the GDP deflator series is relatively more efficient than HICP.

Aksoy and Piskorski (2006) investigate the relationship between changes in real GDP growth and inflation using U.S quarterly data for the period 1966:1 to 1998:2. Using additional explanatory variables such as the money supply and the Federal funds rate, the model was specified as follows:

$$\Delta y_t^r = \beta_1 + \sum_{i=1}^4 \gamma_i \Delta y_{t-i}^r + \sum_{i=1}^4 \delta_i \Delta \pi_{t-i} + \sum_{i=1}^4 \eta_i \Delta DM_{t-i} + \varepsilon_{1t} \quad (2.21)$$

$$\Delta \pi_t = \beta_2 + \sum_{i=1}^4 \gamma_i \Delta y_{t-i}^r + \sum_{i=1}^4 \delta_i \Delta \pi_{t-i} + \sum_{i=1}^4 \eta_i \Delta DM_{t-i} + \varepsilon_{2t} \quad (2.22)$$

where β_1 and β_2 are constants while ε_{1t} and ε_{2t} are the error terms. Equation (2.21) is the real output equation, while equation (2.22) is the inflation equation. Testing for Granger Causality between real output growth and inflation they found that money supply causes output and inflation. Results from the variance decomposition reveals that the interest rate and the money supply have a significant effect on inflation and changes in output.

Zhang and Clovis (2009), employed the Hansen (1999a) grid bootstrap test to study U.S inflation dynamics for the period 1995:1 to 2006:2, using quarterly data. The inflation indicators used are; the GDP implicit price deflator, GDP chain-type price index, personal consumer expenditure chain-type index (PCE) and the CPI with the view of testing which of these measures best explains U.S

inflation dynamics.¹² They modelled inflation persistence of the form:

$$\pi_t = \beta + \rho\pi_{t-1} + \sum_{k=1}^p \phi_k \pi_{t-k} + \varepsilon_t \quad (2.23)$$

where ρ is the inflation persistence parameter, β denotes the intercept, ε_t is the error term and p is the optimal lag order, which is determined by the AIC. Testing for the degree of inflation persistence, using the Andrews-Chen (1993) technique, the GDP deflator produced a value of 0.954. The CPI produced a lower coefficient of 0.894. This shows elements of a unit root present in U.S inflation, especially in the GDP deflator series, as the degree of inflation persistence is close to unity. Applications of dummy variables, with both persistence dummies, $D(1)$ and intercept dummies, $D(2)$ were used to disentangle the source of persistence in inflation.

$$\sum_{j=1}^m D(1)_t \pi_{t-i} + \sum_{j=1}^m D(2)_t \quad (2.24)$$

Combining equation (2.23) and equation (2.24) gives an inflation model of the form:

$$\pi_t = \beta + \rho\pi_{t-1} + \sum_{k=1}^p \phi_k \pi_{t-k} + \sum_{j=1}^m D(1)_t \pi_{t-i} + \sum_{j=1}^m D(2)_t + \varepsilon_t \quad (2.25)$$

Their results shows that up to (17.58 to 20.66%) of instability in inflation is due to the persistence parameter in the GDP deflator and GDP chain-type price index. However, both the persistence and intercept dummies contributed to the source of instability for the CPI and PCE. This study established that the reduction in inflation persistence for the period 1980 - 2006 (also called the Volcker period/Greenspan effect) was largely attributed to a good monetary policy framework.

Collard and Deltas (2010) studied the impact of real vintages on output and inflation for the U.S, using quarterly time-series data for the period 1966:1 to 2002:4. Real vintages is defined as the difference between the actual data at time t and the final or revised data on the monetary policy framework. To comprehend the intuition behind this method, denote money stock in current period as $M_t|_t$ and the growth rate of money stock (representing quarterly vintages) as:

$$g(M_t |)_t = \ln(M_t |_{t+i}) - \ln(M_{t-1} |_{t+i}) \quad (2.26)$$

¹²Clarida et al (2000) argued that the GDP deflator and GDP chain-type price index determined the overall level of inflation in the U.S economy. Inflation was annualised by the conversion: $\pi_t = [\log(\pi_t) - \log(\pi_{t-1}) * 400]$.

Taking into account the effects of “noise” on the money growth stock provides a measure of the unperceived money growth as; $\mu_t | T = g(M_t | T) - g(M_t | t)$. Considering subsample analysis, they documented that real vintages produced volatile shocks which affected output between 1966:1 to 1982:3 but had little systematic effect for the period 1982:4-2002:4. Unanticipated¹³ shocks have a longer impact than anticipated shocks. The significant level of the growth rate of the money stock ranges between 2.68 and 3.5, where unanticipated shocks induced accommodative monetary policy. On the contrary, an insignificant F-statistic in the second subsample (0.92 to 1.105) was explained by the fact that restrictive monetary policy anchored the revised effect on the monetary stock.

Zhang (2011) investigated the importance of China’s inflation dynamics and monetary policy, using quarterly data for the period 1978 to 2009. Inflation was measured using the GDP deflator.¹⁴ The Quandt (1960) and Andrews (1993) approach was used for testing structural change with unknown breaks and probability values determined by Hansen (1997) technique and assuming that inflation follows an autoregressive process, AR(1) model of the form:

$$\pi_t = \beta + \gamma(L_p)\pi_{t-1} + \varepsilon_t \quad (2.27)$$

$$\beta + \gamma(L_p) = \begin{cases} \beta_1 + \gamma_1(L_p), & t \leq \psi \\ \beta_2 + \gamma_2(L_p), & t > \psi \end{cases}$$

According to Zhang (2011), the baseline model shows the impact of backward-looking inflation persistence, where β represents the constant term, $\gamma(L_p)$ denotes a lag polynomial operator determined by the AIC and ε_t is the error term. The term ψ provides an indication of the break date (the year in which structural changes occurred). The Quandt-Andrews test, estimated over the period 1992 - 2009 indicated no evidence of structural change at specified break points (1995:3 and 1995:4) for both the intercept and $\gamma(1)$ with probability values of 0.013 and 0.033 at the 5% level. Zhang’s (2011) analysis could be extended to allow for more lags in the autoregressive process, in view of capturing the dynamic effect of backward-looking inflation which is consistent with the theoretical framework of Gali and Gertler (1999).

¹³A policy is unanticipated when it is implemented immediately after it is announced. It is anticipated when there are lags between announcement and implementation.

¹⁴Zhang (2011) computed the GDP deflator series of inflation as: $\pi_t = [\frac{\pi_t - \pi_{t-4}}{\pi_{t-4}}] \star 100$. This is, the annualized change in inflation between two subsequent quarters.

Zhang (2009) also estimated a VAR model of the output gap, inflation and growth rate of money supply for China's inflation dynamics. The results obtained here were compared to those of Hansen's (1999a) grid bootstrap technique to obtain unbiased estimates of inflation persistence parameters. The first lag and second period shock produce 0.841 by the OLS estimates and 0.881 by the grid bootstrap. Second lag and first period shocks produces 0.702 and 0.753 respectively. This prognosis suggests that significant changes exist in China's inflation persistence, due to high inflation in the 1980's and otherwise low inflation in the 1990's. This has been attributed to good monetary policy through the anchoring of inflation expectations. The conclusion drawn here is that the low inflation persistence in China corresponds to better monetary policy and the anchoring of inflation expectations. Adopting a good monetary policy framework reduces the variability of inflation persistence. These analyses are consistent with the theoretical explanations as was mentioned under the literature review that inflation and structural change affects the conduct of monetary policy.

2.3.3 Review of the Structural VAR and Inflation Dynamics

Studies on the SVAR include: Dungey and Pagan (2000) for the Australian economy, Bagliano and Morana (2003) found that for the U.S economy, long-run fluctuations in output are caused by domestic shocks. Hartley and Whitt (2003), Mutoti (2006), Buckle et al (2007), Huh and Lee (2011), Ostorio and Unsal (2013) and Durevall et al (2013) find that supply shocks accounted for most of the variance in inflation and monetary policy in the U.S, Euro Area and a sample of Emerging market economies and the African economies.

2.4.3.1 Evidence from developed economies

Bagliano and Morana (2003) extended the BQ model by adding an oil price shock and the rate of growth in the money supply to measure the U.S core inflation,¹⁵ employing monthly data from 1960M2 to 2000M4 and using the common trend approach. A cointegrating VAR model was estimated to capture the long-run properties of inflation.

$$z_t = \Pi(L)\Delta z_{t-1} + \alpha\beta' z_{t-1} + \varepsilon_t \quad (2.28)$$

Where z_t contains endogenous variables in the system, ordered as; $z_t = [\text{oil prices,}$

¹⁵This is a measure of the CPI, which excludes transitory price volatility such as energy prices in order to capture the long-run determinants of inflation. This is to say that core inflation is a demand shock.

output, money growth and inflation]’, β' denotes the cointegrating vector, while α represents the speed of adjustment coefficient to long-run structural shocks represented by ε_t . Employing the Johansen (1988) cointegration tests and testing for a unit root, the results divulged that nominal shocks account for over 78% of the variance in inflation and growth rate in money supply while 22% are due to real shocks. The results also indicate that non-core inflation shows a higher correlation of 0.95 than the trend inflation component of 0.66. The emphasis of this study was to show that long-run fluctuations in output are caused by shocks from the domestic economy.

Hartley and Whitt (2003) analyse the determinants of macroeconomic shocks (demand and supply) for five European Union (EU) countries and the U.S, using the GMM. The structural characteristics of the economy are based on the assumption of rational expectations by economic agents. This means that shocks can be decomposed into permanent (long-lasting impact which shifts either demand or supply) or temporary (transitory effects). The aggregate supply schedule can be stated as follows:

$$y_t = \gamma y_{t-1} + \delta(\pi_t - E_{t-1}\pi_t) + s_t \quad (2.29)$$

$$s_t - s_{t-1} = \Delta s_t = s_t^P + s_t^T - s_{t-1}^T$$

where, y_t indicates output gap and π_t represents inflation, γ is the supply persistent parameter. s_t divides supply shocks into permanent (s_t^P) and transitory (s_t^T) components, which are uncorrelated. The second empirical argument postulates the aggregate demand function as:

$$y_t = \delta y_{t-1} - \alpha(i_t - E_t\pi_{t+1} + \pi_t) + d_t \quad (2.30)$$

where, d_t is a demand shock ($d_t - d_{t-1} = \Delta d_t = d_t^P + d_t^T - d_{t-1}^T$), representing shifts in the product market schedule (the IS curve) and $\delta = [-1 < \delta < 1]$ is the demand persistent parameter. It is assumed that both demand and supply shocks are not correlated. Output was measured by industrial production (to avoid disaggregation of GDP data) and inflation by the producer price index (PPI), using quarterly data from 1960 to 1997, obtained from the International Financial Statistics (IFS) of the IMF database. Both industrial production and producer prices were $I(1)$ in Germany, the UK, Netherlands, Italy and U.S, with the exception of France where they are both $I(2)$. The results obtained from this study are two fold. Firstly, demand shocks account for over 70-80% of the variance in output in Germany, France, the Netherlands and U.S, but are most

persistent in Italy and the UK (with a variance of more than 90%). Secondly, temporary supply shocks account for the variance of inflation in the Netherlands, in contrast to France and Italy, where demand shocks account for a large variance in output. This study shows that demand shocks affect the variance of monetary policy more than supply shocks for the sample countries. Testing the effects of partial correlation, supply shocks have a greater impact on the autocorrelation of the variables. The conclusions drawn from this study are that business cycle fluctuations are largely attributed to movements in demand. One caveat of the study is the failure to include more macroeconomic variables such as short-term interest rate or the exchange rate to account for the dynamic impact of other variables.

Using a SVAR model of monthly disaggregated data from 1975 to 1997, Dedola and Lippi (2005) examined the response of monetary policy shocks for the EU area, including the U.S. The basic tenet of their study was to test for the cross-country heterogeneity of the transmission mechanism for an unanticipated monetary policy shock on output.¹⁶ They found a positive output elasticity (derived from cross country correlation) of 0.9, 0.8, 0.7 and 0.5 for France, Italy, U.S and the UK respectively, indicating a large variance in monetary policy shocks to output. These results are highly significant for countries which produce durable goods (industries with stronger financial requirements) and a smaller borrowing capacity.

Buckle et al (2007) used the SVAR approach to measure the impact of external shocks on New Zealand which is a small open economy. This is because New Zealand has a large primary sector, prone to commodity price fluctuations. Using quarterly data from 1983:01 to 2004:02 with thirteen endogenous variables (where output and inflation are detrended, using the HP filter), results indicate that external shocks, including the influence of exports and import prices accounts for a large part of the variation in output and inflation in New Zealand.

Huh and Lee (2011) employed the SVAR framework in their analysis of the UK's core inflation. Their main motivation was to examine a multivariate model of core inflation shocks, which is represented by the variables money demand, money supply and investment savings and non-core inflation shocks such as oil prices, productivity and labour supply.¹⁷ Denoting core (demand) and non-core inflation (supply) shocks as; ε_t^c and $\varepsilon_t^{\bar{c}}$ respectively, the model can be represented

¹⁶Peersman and Smets (2002) using similar framework in an earlier study for 7 EU countries found high cross-country heterogeneity.

¹⁷This is an extension of the Quah and Vahey (1995) approach, used as a benchmark model by Huh and Lee (2011).

as follows:

$$\begin{bmatrix} \Delta y_t \\ \Delta \pi_t \end{bmatrix} = \begin{bmatrix} \beta_{11} & 0 \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{\bar{c}} \\ \varepsilon_t^c \end{bmatrix} \quad (2.31)$$

where Δy_t and $\Delta \pi_t$ represent the first difference operator for the output gap and inflation respectively. The main idea was to decompose inflation so that core inflation shocks have no long-run effect on the levels of real output ($\beta_{12} = 0$) which is consistent with the BQ condition. Given this analytical framework, Huh and Lee (2011) used monthly data, for the period 1969:03 to 2000:12 to examine the UK's core inflation. The variables used were; industrial production as a proxy for GDP, inflation which is measured as a percentage change in the retail price index (RPI) and HICP. The instrument in the SVAR model includes: the nominal interest rate (measured as the yield on 3 months treasury bills), money supply, real oil price (indicating non-core inflation or supply shock) and labour hours. They revealed that supply shocks accounted for more than 80% of the variance in inflation. The RPI and HICP did not provide good estimates of forecast performance for inflation (Huh and Lee, 2011).

Canova and Ferroni (2012) studied the sensitivity of inflation volatility and monetary policy shocks for the U.S, using the SVAR. They seek to address whether the SVAR approach is a more plausible technique for modelling U.S inflation, using quarterly data from 1959:1 to 2006:1. The variables used were the interest rate, real money balances, inflation and GDP. Persistence was measured by using lagged autocorrelation coefficients from the SVAR model and generated IRF to ascertain the extent to which shocks will last. The variance decomposition was employed to determine how much of the explanatory variables are explained by shocks to technology, demand (money demand and government expenditure) and monetary policy. The results reveal that monetary policy paid more attention to reducing inflation than output growth in the early 1980's than they did in the 1970's. They established that negative shocks affected inflation volatility in the early 1970's because of accommodative monetary policy, while positive shocks caused by restrictive monetary policy affected output and inflation volatility in the early 1980's.

2.4.3.2 Evidence from Asian economies

One of the main studies of Asian economies has been Osorio and Unsal (2013) who used a SVAR analysis to identify aggregate demand and aggregate supply shocks for 33 countries (12 Asian countries), using quarterly data for 1986:01

to 2010:1. They were aiming to determine how commodity price shocks affect inflation and output and hence the impact of trade (financial linkages) on inflation dynamics. Using real output, inflation (measured by the CPI and PPI), real money balances, a commodity price index and the interest rate, the following results were obtained. Firstly, approximately 45% of the variance in inflation is explained by aggregate supply shocks in Asia, with commodity price representing over 30%. This indicates that demand shocks account for approximately 55% of the variation in inflation, mainly due to changes in the money supply (25%) and the exchange rate (15%), particularly for large open economies like Korea and Indonesia. Secondly, in Australia and New Zealand, commodity price shocks accounted for less than 10% of the variance in inflation. Thirdly, in countries where the impact of domestic demand is greater as in India, China, and Indonesia, the effect of inflation is large (approximately 60%). The conclusion drawn from this study is that there is a large effect from inflation pass-through from China.

2.3.4 General Overview of Studies in the African economies

A substantial amount of literature on inflation dynamics and monetary policy has focused on developed economies with limited research having been done on the African economies, where monetary policy in recent years has become effective in controlling inflation and increasing output growth. This section introduces some general studies on monetary policy in the African economies, in order to understand their monetary policy frameworks. Buigut and Valev (2006) used the SVAR approach to determine the correlation coefficients from contemporaneous aggregate demand and aggregate supply shocks in 21 Eastern and Southern African economies. Their aim was to determine the possibility of forming a monetary union based on these shocks from aggregate demand and aggregate supply. They used a bivariate model of output growth¹⁸ and inflation, with an identification scheme similar to that of the BQ framework that demand shocks have no long-run impact on output growth, using annual data over the period 1971 to 2002. They found weak evidence of the linkage between contemporaneous aggregate supply and demand shocks with regard to the formation of a monetary union.¹⁹ The results from the impulse responses indicate that the magnitude of shocks across countries is also small and mostly insignificant. So little evidence to support a monetary union.

¹⁸Output was measured as the first log difference of real GDP and inflation by the implicit GDP deflator.

¹⁹Where positive correlations indicated symmetric effects toward the formation of a monetary union while negative correlations implied asymmetric responses, without the possibility of monetary integration.

Saxegaard (2006) studied the relationship between excess liquidity and monetary policy effectiveness for Nigeria, Uganda and the Central African Economic and Monetary Community (CEMAC) member countries²⁰ from the period 1990:1 to 2004:4. The TVAR approach is used and the threshold variable is defined in terms of excess liquidity propagating shocks to the economy. This is measured as the liquid holdings over the minimum reserve requirements which were set by the central bank's of the sample of African economies. The study finds that the excess liquidity affects the effectiveness of the central bank in conducting monetary policy, through its influence on the level of aggregate demand in the economy. A key feature of this study was in Uganda, where large inflows of foreign aid from the IMF and the World Bank concessionary lending initiatives had an inflationary impact on the economy. This is to say that inflation in Uganda resulted from the increase in the money supply.

Durevall and Sjo (2012) examined the determinants of inflation in Kenya and Ethiopia using monthly data over the period 2000 to 2011. Using the Error Correction Model (ECM), they found that global food prices and the depreciating exchange rates affected long-run inflation in both countries, while the short-run determinants of inflation were the money supply and domestic supply shocks. The conclusion drawn from this study indicates that inflation in Kenya and Ethiopia may have been brought about by expansionary monetary policies in an attempt to control inflation, that resulted from negative supply shocks such as droughts.

Akinbobola (2012) analysed the determinants of inflation in Nigeria for the period 1986:01 to 2008:04 by using the Vector Error Correction Mechanism approach. The sample starts in 1986, where the structural reform programs were implemented in Nigeria, as part of the IMF's stabilisation programmes which were aimed at achieving broad macroeconomic objectives, including price stability and economic growth. The results obtained indicated that inflation in Nigeria is caused by increases in the money supply. These results are consistent with the fact that the Central Bank of Nigeria (CBN) had targeted the rate of growth in the money supply as the main policy instrument for influencing changes in the real economy, until 2007 where the interest rate was adopted as the main instrument.

²⁰This include Cameroon, Chad, Central African Republic, Equatorial Guinea, Gabon and the Republic of the Congo. The aim of the monetary union is to promote regional economic integration among its member countries, where fiscal policy dominates the monetary policy framework.

Using a country-specific quarterly dataset between 1996 to 2010, Caceres et al (2013) analysed the determinants of inflation in the CEMAC member countries, following its establishment in 1994. The results obtained from using a panel cointegrated VAR approach indicated that global commodity food prices are the main determinants of inflation in the CEMAC region, which resulted from inflation pass-through effects across the member countries. The study also indicated that apart from commodity price shocks causing inflation, structural rigidities in the form of government policies, through controlled prices and fiscal deficits were inflationary in the CEMAC region.

Durevall et al (2013) examined the determinants of inflation in Ethiopia, using monthly data for the period 1999:01 to 2009:12, obtained from the National Bank of Ethiopia and the Food and Agricultural Organization (FAO). Their motivation was to determine how monetary policy responded to inflation (measured by the rate of change of the CPI) arising from the global food crisis between 2004 to 2008. Using the general-to-specific method²¹ with an ECM of inflation, results indicate that supply shocks for primary commodities determine short-run food inflation, in contrast to the growth rate of the money supply for non-food inflation. The impact of domestic food supply shocks, led to a negative coefficient for the output gap of 0.7, while food commodities such as cereal prices accounted for more than 22.54% of the variation in inflation. These results indicate that accommodative monetary policy may be responsible for inflation during this period. The conclusion drawn from this study suggests that food prices and domestic supply shocks are important contributors to inflation and the monetary policy transmission mechanism and therefore, including these shocks explains important asymmetric relationships in Developing Country's monetary policy.

Kasidi (2013) investigated the impact of inflation on economic growth in Tanzania, using annual data which spanned 1990 to 2011. The empirical model consists of output growth, which was measured as the first log difference of real GDP (y_t^r) and inflation (π_t) by the CPI.

$$y_t^r = \alpha_0 + \alpha_1 \pi_t + \varepsilon_t \quad (2.32)$$

Where, ε_t is the error term, α_0 is the constant term and α_1 measures the coefficient of elasticity of inflation with respect to real output growth. The results obtained show that inflation has a negative effect on the Tanzanian output growth rate following the estimation of equation (2.32) by the least squares approach. This

²¹See Hendry and Krolzig (2005) for an analysis of the deductive approach in Econometric modelling.

study also finds that inflation and economic growth are not cointegrated in Tanzania, meaning there is no long-run relationship existing between the two variables. The policy implication derived from this study suggests that in order to improve economic growth in Tanzania, the monetary authorities should aim to target inflation to the level required to maximise output growth. However, as mentioned previously, there is little empirical work on the transmission mechanism in Africa.

2.3.5 Review of the Empirical Literature on the TVAR Model

This section does not aim to analyse the entire literature of the TAR/TVAR model, as the list will be exhaustive but rather to provide a concise account of the main influential papers. In this section, we have surveyed the current literature on threshold models with the intention of identifying gaps in the literature and a potential contribution. Although much research on the TVAR model has been conducted on developed economies, they are however, likely to have important implications for developing economies where limited research has been conducted so far. A common theme in the application of the SETAR models has been output growth,²² the exchange rate, money supply and financial market conditions (measuring credit regimes).

The literature distinguishes between the application of bi-variate and multi-variate threshold models. Considering the first scenario of a bi-variate application, Altissimo and Violante (2001) assesses the non-linear interaction between output (measured as real GDP) and unemployment for the U.S economy. That is they modelled the labour market for the U.S by focusing on the transmission mechanism between deviations in real GDP and unemployment using the TAR model. In distinguishing between the effects of asymmetric relationships, non-linearity is particularly evident for unemployment, whilst the transmission mechanism affects output via cross correlations. The policy implications suggest that asymmetric effects are associated with faster economic recovery (from a recession) in subsequent periods over the medium to long-run.

Another contribution of the dynamic applications of the TAR model for the

²²This was motivated by Fischer (1993) who first proposed the existence of a non-linear relationship between inflation and economic growth. Huang et al (2005) investigated the impact of oil price changes on economic activity, measured in terms of industrial production and the real stock returns for the U.S, Canada and Japan using a TVAR model and monthly data for the period spanning 1970 to 2002.

U.S, UK and Turkey is by Balke (2000), Atanasova (2003) and more recently Catik and Martin (2012) respectively. Balke (2000) investigated the impact of credit on financial market frictions by estimating a TVAR model; allowing for switching between tight credit regimes, which are used as a non-linear propagator of shocks in the U.S. Using quarterly data from 1960:01 to 1993:3 consisting of output growth, inflation, the Federal funds rate and commercial paper (measuring credit conditions, as the threshold variable). This is defined as the ratio of the four-to-six month treasury bills spread. Results from the non-linear IRF show that non-linearity implied by regime switching contributed to output fluctuations as well as credit shocks. That is output responds more to monetary policy in a credit rationed regime. Balke (2000) cautioned that although credit conditions propagate shocks in the U.S economy, they do not necessarily imply an important source of shocks. The paper concludes with strong evidence of non-linearity between credit conditions and output fluctuations. This suggests monetary policy has a stronger effect on output when it exceeds a certain threshold (tight credit conditions).

Atanasova (2003) examined whether credit market imperfections are central to the propagation of cyclical fluctuations from macroeconomic shocks, using monthly data for the UK from 1984M1 to 2002M4. The supremum-Wald statistics of Hansen (1996) were used to test for evidence of non-linearity in the credit markets (measured as the corporate spread²³) and including other macroeconomic variables such as industrial production as a proxy for output growth, the inflation rate, which is measured as the annual rate of the RPI and money supply (M2) as the indicator for monetary policy. The conclusions drawn from the study reveal that monetary policy has real effects on the economy when the corporate bond spreads exceeds a threshold of 1.31%, which is analysed by the non-linear IRF.

More recently, Catik and Martin (2012) used monthly data from 1986M1 to 2010M11 to determine endogenous transmission between regimes in Turkey following the macroeconomic reforms enacted in early 2000. They found evidence of non-linearity in the pre and post 2003-2004 periods, using inflation and interbank rate as the threshold variables. They concluded that the transmission mechanism of monetary policy has changed over time, as observed through less persistence to shocks in the post reform regime and with monetary policy explaining a more significant proportion of the variance in the output gap.

²³This is defined as the yield on 10 year investment corporate bonds less a similar maturity on risk free government bond (Atanasova, 2003). The main argument is that commercial paper and treasury bills are both short-term debt instruments, which do not capture long-term debts.

2.4.4.1 Applications to Output Growth

Cover (1992) employed a SETAR model for the U.S using data from 1951:01 to 1987:04 and found that negative and positive money shocks have asymmetric effects on output. Beaudry and Koop (1993) examined whether negative innovations to GNP (y_t^r) are more persistent than positive innovations based on an ARMA representation of output. They measured the GNP²⁴ growth rates as a function of the deviation of the current level of GNP. They found evidence of deviations from past output to current output growth. Their results concluded with the finding that positive innovations are more persistent than negative shocks. This is to say that recessionary shocks are more persistent than expansionary shocks. In another study, Pesaran and Potter (1997) found similar evidence in support of Beaudry and Koop (1993) regarding non-linearity in the U.S GNP. Using Bayesian estimations, Koop and Potter (1999) found asymmetries in the U.S unemployment rate²⁵. The implication is that unemployment rises sharply during recessions and falls gradually as the economy recovers from the shock to output.

2.4.4.2 Evidence from the Exchange Rates

Taylor (2001) documented that the failure to account for non-linear dynamics of exchange rate may produce wrong interpretations on the level of persistence and the degree of mean-reversion (which is the speed of adjustment to the steady state long-run equilibrium) of the exchange rate. Sarno et al (2004) investigated the relationship between bilateral exchange rates, using the TAR model to test for asymmetric relationships. In another study, Balke and Wohar (1998) use monthly data from 1974M1 to 1993M9 for the UK/US spot and forward exchange rates and interest rate to measure deviations from covered interest parity. They find that non-linearity stemmed from asymmetric transactions costs due to deviations from covered interest parity.

2.4.4.3 Evidence from the Interest Rate

Empirical evidence on univariate threshold models focuses on the term structure of interest rate. A notable example is Tsay (1989, 1998) who used the threshold regression model, based on the predictive residuals from U.S interest rates. The

²⁴This is the real quarterly GNP obtained from Citibase, GNP (1982).

²⁵Koop et al (1996) also develop methods for impulse response analysis in non-linear multivariate models. They argue that linear models may not capture asymmetries that may exist in business cycle fluctuations.

study reveal a strong non-linear response of interest rate changes to the spread. Pfann et al (1996) in another study also examined the term structure of interest rates for the U.S economy by using a two regime TAR model. The short-term interest rate is the conventional 90 days (3-months) treasury bills rate, while the 10 year government bond is used as the long-term interest rate. The conclusion drawn from the study of Pfann et al (1996) is that the yield on interest rate decreases as the short-term interest rate increases.

2.4.4.4 Evidence from the African economies

Studies aimed in this area at estimating the threshold level beyond which inflation affects output growth for African economies include; Khan and Senhadji (2001) who found inflation threshold estimates of 7-11% for developing economies over the period 1960 to 1998. Their aim was to examine the relationship between inflation and output growth in order to determine what level of inflation is necessary to produce an efficient level of economic growth, using an unbalanced panel data for 140 countries.²⁶ Frimpong and Oteng-Abayie (2010) examined the relationship between inflation and economic growth for Ghana using annual data for the period 1960 to 2008. Their results indicate an inflation threshold level of 11% at which economic growth is maximised. This is consistent with the results obtained by Khan and Senhadji (2001). Two major conclusions can be drawn from the study of Frimpong and Oteng-Abayie (2010). Firstly, inflation has a moderate impact below the threshold value of 11% but it has considerable impact on economic growth above the threshold value. Secondly, the Bank of Ghana (BoG) was efficient in controlling inflation during the period of the study, as the year-on-year inflation target of 6-9% did not exceed the optimal inflation threshold (of 11%). Phiri (2012) found an inflation threshold level of 8% between 2000 to 2010 for the South African economy, using a univariate TAR model.

These studies are important to understand the relationship between inflation and economic growth, of a sample of the African economies. However, they are not without limitations. Firstly, they assume a fixed range for searching the optimal inflation thresholds. Khan and Senhadji (2001) considered a possible inflation range between 7% to 12% while Frimpong and Oteng-Abayie (2010) used 6 - 12% at which the relationship between inflation and economic growth is maximised. This has a limitation due to the fact that the optimal inflation

²⁶ Data for inflation (which is used as the threshold variable) and GDP were obtained from the World Economic Outlook of the IMF.

thresholds may exceed the range over and below which inflation is estimated. Secondly, they focused mainly on the relationship between inflation and output, without considering the monetary aspects of the economy, that may have had a significant effect on inflation dynamics. This is due to the fact that most of the African economies are inflation targeting countries.

2.3.6 Review of the Literature on the BVAR Model

In recent years, the BVAR approach has gained renewed interest in the literature in order to explore changes in the economy. For example, Carriero et al (2009) have employed the Bayesian estimation framework for predicting exchange rate, while Canova and Ciccarelli (2004) applied the Minnesota prior to a Bayesian Panel VAR framework. Among the most often cited studies in the literature there is: Litterman (1984, 1986), Kadiyala and Karlsson (1997), Robertson and Tallman (1999), Ciccarelli and Rebucci (2003), Giannone and Reichlin (2006), De Mol et al (2008), Banbura et al, (2010), Koop and Korobilis, (2010) and Koop (2010). These studies share a common conclusion in that Bayesian inferences are capable of improving the changes in the performance of macroeconomic variables compared to the unrestricted VAR models.

Given that VAR models are often overparameterised, Banbura et al (2010) have developed a Bayesian shrinkage technique based on the work of De Mol et al (2008) for models containing large data sets, which is based on the Minnesota approach in order to address the dimensionality problem of unrestricted VARs. This is the tendency that increasing the lag length or the number of variables reduces the degrees of freedom as well as the fit of the model. The Bayesian shrinkage approach uses the average of the mean squared forecast error (MSFE) from the output gap, inflation and the interest rate as potential indicators for measuring the overall level of uncertainty of the economy on which monetary policy decisions are made. Koop (2010) suggested that the MSFE is the most commonly used measure of forecast performance in Bayesian analysis.

Auer (2010) uses Gibbs sampling for examining the impact of a contractionary monetary policy shock to the U.S policy rate. The study finds that the exchange rate appreciates with no evidence of a price puzzle; meaning that a contractionary monetary policy induces decreases in the price level based on Monte Carlo simulations with 200 draws over a 16 period horizon.

2.4 Table of Studies

Table 2.1: Empirical Studies of Inflation Persistence and Structural Change

Study	Country	Data	Technique	Findings
Clarida et al (2000)	U.S	1960Q1 - 1996Q4	GMM	Found significant changes in the U.S monetary policy between the pre and the post Volcker periods.
O'Reilly and Whelan (2005)	Euro Area	1970Q1- 2002Q4	OLS	The presence of structural inflation persistence within the Euro Area, was mainly attributed to the changes in monetary policy framework.
Aksoy and Piskorski (2006)	U.S	1966Q1 - 1998Q2	ARDL & VAR	Domestic money supply caused inflation
Zhang and Clovis (2009)	U.S	1995Q1 - 2006Q2	OLS	Monetary policy tightening led to reductions in inflation persistence in the post 1980 period.
Collard and Dellas (2010)	U.S	1966Q1 - 2002Q4	VAR	Found evidence of the money supply causing inflation.
Zhang (2011)	China	1978Q1 - 2009Q4	OLS & VAR	The effects of structural breaks in China's monetary policy were caused by regime changes.

Source: A concise summary of the literature review.

Table 2.2: Empirical Studies of Structural Identified VARs

Study	Country	Data	Technique	Findings
Bagliano and Morana (2003)	U.S	Monthly data from 1960M2 - 2000M4	Cointegrated VAR	Long-run fluctuations in output and inflation are caused by shocks from the domestic economy.
Hartley and Whitt (2003)	6 Developed Countries	1960Q1- 1997Q4	GMM	There is evidence that business cycle fluctuations are largely attributed to movements in demand.
Dedola and Lippi (2005)	Euro Area & U.S	Monthly disaggregated data from 1975 - 1997	SVAR	Monetary policy influences changes in output especially for countries which produce durable goods and with smaller borrowing capacity.
Buckle et al (2007)	New Zealand	1983Q1 - 2004Q2	SVAR	External shocks accounted for a large variation in output and inflation.

Source: A concise summary of the literature review.

Table 2.2: Empirical Studies of Structural Identified VARs (Cont'd)

Study	Country	Data	Technique	Findings
Huh and Lee (2011)	UK	1969M3 - 2000M12	SVAR	Supply shocks accounted for over 80% of the variance in inflation.
Canova and Ferroni (2012)	U.S	1959Q1 - 2006Q1	SVAR	Found evidence of changes in U.S monetary policy affecting output and inflation, in particularly during the pre and the post Volcker periods.
Osorio and Unsal (2013)	33 Countries	1986Q1 - 2010Q1	SVAR	There is mixed evidence regarding the variance decompositions of the output gap and inflation. In countries where the impact of domestic demand is greater as in India, China, and Indonesia, the effect of inflation is large (approximately 60%).

Source: A concise summary of the literature review.

Table 2.3: General Overview of Studies in the African economies

Study	Country	Data	Technique	Findings
Buigut and Valev (2006)	21 African economies	1971 - 2002	VAR	Finds weak evidence against the fact that the contemporaneous aggregate demand and aggregate supply shocks may be useful in determining whether countries qualify toward joining a monetary union.
Saxegaard (2006)	8 African economies	1990Q1- 2004Q4	TVAR	Found evidence of excess liquidity affecting the conduct of monetary policy.
Durevall and Sjo (2012)	Kenya and Ethiopia	Monthly data from 2000 - 2011	ECM	Short-run determinants of inflation were the domestic money supply and aggregate supply shocks, while commodity price and exchange rate depreciation affected long-run inflation.
Akinbobola (2012)	Nigeria	1986Q1 - 2008Q4	VECM	Found evidence of the money supply causing inflation.
Caceres et al (2013)	6 CEMAC Countries	1996Q1 - 2010Q4	Panel Cointegrated VAR	There is evidence of fiscal policy dominance over monetary policy framework as well as commodity price shocks causing inflation.
Durevall et al (2013)	Ethiopia	1999M1 - 2009M12	ECM	Supply shocks determined the short-run inflation dynamics.
Kasidi (2013)	Tanzania	1990 - 2011	OLS & Cointegration	A negative relationship exists between inflation and output growth, with no cointegration existing between the two variables.

Note: CEMAC means Central African Economic and Monetary Community.

Table 2.4: Empirical Studies of Threshold Non-Linearities

Study	Country	Data	Technique	Findings
Pfann et al (1996)	U.S	1962M1 - 1990M6	TVAR	Found evidence of non-linearity in the interest rate. This means that the yield on interest rate decreases as the short-term interest rate increases.
Balke and Wohar (1998)	U.S	1974M1 - 1993M9	Threshold Cointegration	Non-linearity arises from asymmetric transaction costs due to deviations from covered interest parity.
Balke (2000)	U.S	1960Q1- 1993Q3	TVAR	Finds evidence of non-linearity between credit conditions and output fluctuations. This implies output responded more to monetary policy in a credit rationed regime.
Khan and Senhadji (2001)	140 Countries	1960 - 1998	GLS & 2SLS	Found that optimal inflation thresholds ranges between 7-11% for developing countries.

Source: A concise summary of the literature review.

Table 2.4: Empirical Studies of Threshold Non-Linearities (Cont'd)

Study	Country	Data	Technique	Findings
Atanasova (2003)	UK	1984M1 - 2002M4	TVAR	There is non-linearity between monetary policy and credit regimes when the corporate bond spreads exceeds a threshold of 1.31%.
Frimpong and Oteng-Abayie (2010)	Ghana	1960 - 2008	TVAR	The relationship between inflation and economic growth is maximised when inflation is at 11% of the threshold value.
Phiri (2012)	South Africa	2000 - 2010	TVAR	The study established evidence of non-linearity in the inflation rate when the threshold value exceeds 8%.
Catik and Martin (2012)	Turkey	1986M1 - 2010M11	TVAR	Found evidence of asymmetric effects in the monetary policy transmission mechanism.
Mandler (2012)	U.S	1965Q3 - 2007Q2	TVAR	Monetary policy in the U.S is regime- dependent, which is propagated by the non-linearity in inflation.

Source: A concise summary of the literature review.

2.5 Conclusions and Identifiable Gaps

The summary of the literature review suggests the use of different transmission mechanism for the inflation dynamics. It is evident from the literature that the NKM is the hallmark from which backward-looking inflation is indexed and forward-looking expectations are derived. This body of knowledge has led to

different empirical applications in the conduct of monetary policy and questions about how monetary policy responds to inflation persistence and expectations about the economy? This is to say to what extent does the NKM explain inflation driven by policy shocks?

Drawing from the theoretical framework, five conclusions can be identified. Firstly, given uncertainty about the degree of inflation persistence and hence misperception about the true impact of inflation, this affects the conduct of monetary policy (Amano, 2007). Monetary policy may assume that the perceived inflation persistence is less than the actual inflation persistence when conducting monetary policy. The literature also suggests that inflation persistence stems from lagged inflation, which also provides information on monetary policy. Secondly, how is inflation persistence measured? The literature documents that lagged inflation captures inertia and thus persistence in monetary policy. The main argument is that a change in central bank targets may not be captured by lagged inflation (O'Reilly and Whelan, 2005). However, Gali and Gertler (1999) argue that backward-looking inflation may provide an explanation of price-stickiness or inflation inertia. Thirdly, the efficacy of interest rate smoothing is to introduce partial adjustment to the central bank nominal interest rate to smooth changes in inflation and the output gap (Clarida, et al 2000). This explains why monetary policy uses interest rate to influence changes in the output gap and inflation (Rafiq and Mallick, 2008). Fourthly, the identification of shocks (through either contemporaneous short-run restrictions, long-run or sign restrictions), captures central bank behaviour and the dynamic structure of the economy. It also helps to capture the persistence of shocks through dynamic IRF and FEVD, unlike measuring persistence with lagged inflation. The TAR/TVAR model is relevant in determining optimal threshold levels beyond which macroeconomic variables impact on the conduct of monetary policy. And finally, the BVAR approach has been introduced into studies of applied macroeconomics as a means of addressing the dimensionality problem which is often cited as the main limitation with unrestricted VAR models (Doan et al, 1984).

The following features stand out clearly from the review of the empirical literature. Firstly, high inflation persistence may result from loose (accommodative) monetary policy, which is indicative of the fact that discretionary monetary policy rules are inclined to high inflation, which is consistent with the Barro and Gordon (1983) (BG) monetary policy postulate analysis. Another prognosis suggests that low inflation signals monetary policy effectiveness and the credibility of the central bank to capture inflation inertia and hence expected inflation (Zhang and

Clovis, 2011). Secondly, comparing the volatility between output and inflation, output gaps are more persistent than inflation gaps (Aksoy and Piskorski, 2006). This result may imply that consideration of the changes in the business cycle is required when modelling the monetary policy transmission mechanism. This is to account for changes in macroeconomic fluctuations, when measuring the output gap. Thirdly, the results from the VAR frameworks supports the finding that supply shocks account for a large variance in inflation persistence, although variations exist across countries. Evidence also suggests that the impact of shocks to inflation and output are large for more open than closed economies (Osorio and Unsal, 2013). There is a growing body of literature on the developed economies, with limited research having been conducted on the African economies.

This study makes the following contributions which are commensurate with the identifiable gaps in the literature review. The first contribution is to determine structural breaks in macroeconomic variables. This is to understand the evolution of monetary policy in the African economies. The second contribution of the thesis is to investigate monetary policy effectiveness by using the SVAR approach. The main objective is to determine which policy instrument: the exchange rate or interest rate is more effective for the transmission mechanism of monetary policy shocks, given that the African economies have become more market oriented. Inflation dynamics are examined by empirically identifying the decomposition of shocks in the economy and using the New Keynesian framework. This is based on the assumption that shocks are the dynamic effects of aggregate supply, aggregate demand, money supply, money demand, commodity price shocks and exchange rate shocks. This method is an extension to the literature by analysing the transmission mechanism of monetary policy, rather than modelling a univariate model of inflation persistence. The third contribution of the thesis is to determine the efficient inflation thresholds at which the relationship between inflation and monetary policy is maximised. Lastly, the fourth contribution of the thesis is to explore the performance of the monetary policy transmission mechanism in the sample of African economies, using the BVAR approach. The next chapter provides an overview of monetary policy in a sample of African economies from which the research design is based.

Chapter 3

Policy Background on the African economies

3.1 Introduction

Prior to the 1970's, African economies experienced stable rise in real GDP growth during the Bretton Woods era with a fixed exchange rate mechanism. Policy objectives during this period were geared towards stability of the exchange rate to achieve a favourable balance of payments to increase output growth. But inflationary tendencies that emerged in the 1970's, following persistent oil and commodity price shocks and the collapse of the fixed exchange rate system, created asymmetric price adjustments in the monetary policy framework.

This in turn led to depreciation of the exchange rate mechanism and as such, other policy instruments were needed to stabilise output and inflation. This included monetary targeting, initiated in the early 1990's by most of these countries, although events characterized by the Stock market crash in the mid 1980's and deregulation of financial markets, affected credit expansion. These pressures in most African economies were characterized by external shocks and internal disequilibrium (Kumar and Okimoto, 2007). However, episodes of inflation persistence were common in many countries, including the U.S, prior to the 1980's (Benati, 2008). Following Mishkin (2007b), Figure 3.1 shows the evolution of inflation for selected developed economies, in comparison with those of the African economies. This is to provide a snapshot of trends in inflation rates, which can be related to changes in the business cycle and the monetary policy framework, in the later analysis.

Fig A: Inflation rates in the U.S, Canada and Japan

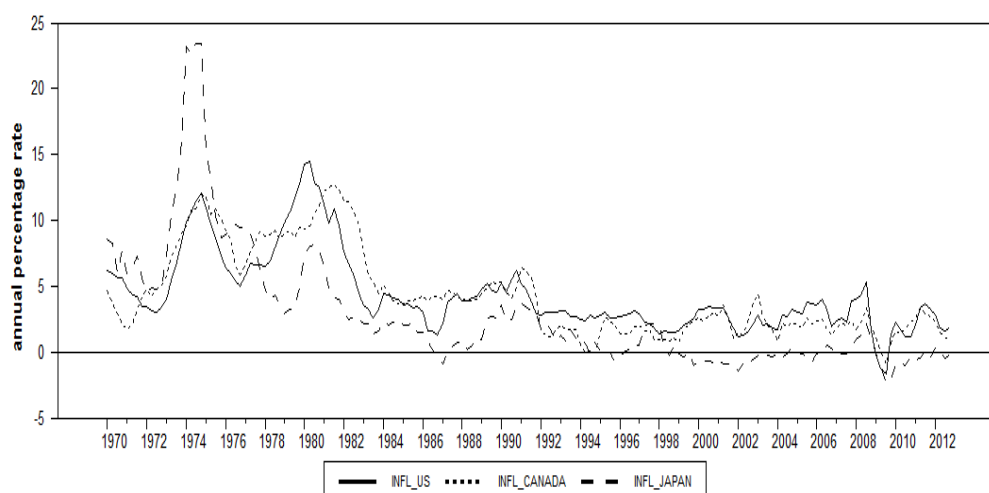


Fig B: Inflation rates in Algeria, Kenya and South Africa

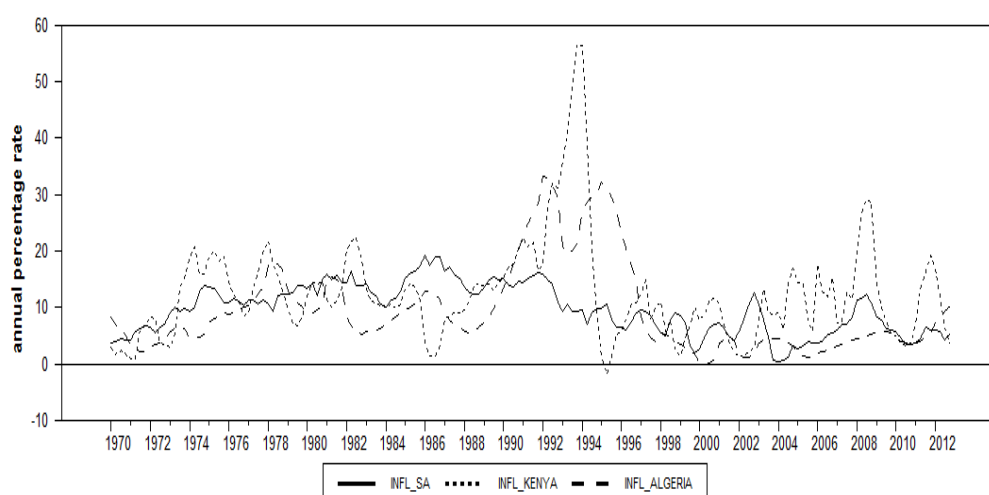


Figure 3.1: Comparison of Annual Inflation in developed economies (Panel A) and a selection of African economies (Panel B).

In sharp contrast to the developed economies, Panel B shows that inflation soared in most African economies in the mid 1990's, in the wake of SAP and macroeconomic reforms. By the early 1990's, inflation had gone down in the developed economies.¹ This chapter seeks to describe the policy background for selected African economies, namely; Algeria, Botswana, Ghana, Kenya, Nigeria, South Africa, Tunisia and Uganda. The aim is to provide an evolution of exchange rate and monetary policy frameworks. The definition of monetary policy framework as used in this chapter is the process through which central bank's interest rate, the growth rate in money supply or with floating or managed floating exchange rate influence changes in the real economy (IMF, 2014).

¹Lower inflation rates further led to the creation of the EU in 1999 for countries in Europe.

The organization of this chapter is as follows. Following the introduction, section 3.2 introduces details on stabilization and SAP to shed some understanding on the exchange rate and monetary policy framework. Section 3.3 explores the exchange rate arrangements of the sample economies. An overview of the monetary policy framework is discussed in section 3.4. Section 3.5 summarises the monetary policy regimes. Section 3.6 considers the implications of an inflation targeting framework for a selection of the African economies, while section 3.7 concludes the chapter.

3.2 SAP and Stabilization Measures

In an attempt to provide a basis for the monetary policy framework of the sampled economies, this section discusses the impact of SAP and stabilization programmes initiated by the World Bank and IMF in most African economies in mid 1980's to the early 1990's through the provision of loans, which were designed to overhaul the structures of the economies by improving long-term economic growth, remove debt burden, increase financial stability and credit expansion as well as banking reforms. These structural adjustment loans or concessionary lending were attached for specific purposes, meant to limit government intervention which are believed to have caused structural rigidities, under the framework of deregulation of markets and prices by removing credit ceilings and preferential interest rates, as well as trade liberalization (Heidhues and Obare, 2011). These loans were conditional on long-run economic growth through improvements in domestic macroeconomic policies in the African economies.

SAP focused on institutional frameworks such as deregulatory policies, mostly included privatisation of state-owned companies to promote market competition, while salary reduction invariably decreased real consumer spending. Trade liberalization through it increased free trade, currency devaluation and a managed balance of payments contributed to low GDP growth (IMF, 2014). This is because trade liberalization requires efficient markets which indirectly exacerbated many of Africa's problems due to the shallow nature of financial markets in Africa. In Botswana, in 1999 SAP eliminated exchange rate controls and currency devaluations in 2005. This was followed by trade liberalization in 2001 to improve its economic and financial stance and help its development of long-run growth. It is believed that SAP affected the level of economic growth in African economies as it emphasises on growth in the private sector through the liberalization of state-owned companies and free market developments, with neglecting of the developments in the public sector (Fosu, 1999; Ikejiaku, 2008 and Heidhues and

Obare, 2011).

3.2.1 Stabilization Measures

In contrast to SAP, stabilization measures were related to broad macroeconomic aggregates such as reducing the overall rate of inflation, through contractionary monetary policy accompanied by budget cuts (due to the debt crisis) as part of the conditionality clause made under the Heavily Indebted Poor Countries (HIPC) initiatives. The IMF in conjunction with the World Bank introduced HIPC initiatives in 1996, to reduce the debt burden, increase economic and financial policy and the development of long-run growth. The aim was to improve structures of the qualifying countries (Ghana, Kenya and Uganda, within the sampled countries), based on the enactment of institutional and macroeconomic policies.

For instance, Ghana joined the HIPC initiative in 2000, with their external debts amounting to US\$577 million in 1980 (approximating to over 114% of GDP). Prior to HIPC, SAP was initiated in Ghana in 1983, under the acronym of the Economic Recovery Program (ERP) as revenue from cocoa production dropped dramatically in the 1970's. ERP aimed at resolving balance of payments deficits by encouraging competitive markets and efficiency and removing government subsidies and tariffs. The decision to qualify Uganda² for HIPC funds in 1997 was because its external debt between 1986 and 1994 rose by 121%, from US\$1.4 billion to US\$ 3.2 billion.

Algeria, Botswana, Nigeria, South Africa and Tunisia, did not qualify for the IMF and the World Bank HIPC funds due to strong economic policies and the contribution from natural and mineral resources (such as diamonds in the case of Botswana, oil in Nigeria, hydrocarbons in Algeria, petroleum production in Tunisia and the contribution from the service sector in South Africa). The next section introduces the exchange rate policies for this sample of the African economies.

3.3 Exchange Rate Arrangements

3.3.1 Introduction

Exchange rate policy in African economies has undergone several transitions, since the collapse of the Bretton Woods system of fixed exchange rate. While

²Uganda was the first country to qualify for the enhanced HIPC initiative, which was introduced by the World Bank due to large external debts.

most developed economies³ adopted a floating exchange rate to maintain the value of their currency, most African economies considered an eclectic approach, characterized by floating, managed floating, a crawling peg and other managed arrangements. Devaluation of the currency that accompanied SAP became a nominal anchor to increase domestic competitiveness, coupled with a strong monetary policy framework to reduce inflation.

Exchange rate regimes are generally classified as fixed or floating (flexible). In a floating exchange rate, the value of the currency in terms of another is market determined with a predictable path for the rate. The currency is allowed to fluctuate according to market conditions, which may induce volatility depending on the size of the economy. In a managed float, the exchange rate is allowed to float, but subject to interventions by the central bank. In a crawling peg system, the fixed exchange rate is continuously adjusted, based on inflation differentials of the country, relative to its trading partners. Alternatively, in a crawl-like arrangement, the exchange rate is targeted within a narrow margin of 2% for six months or more (IMF, 2013).

According to the IMF (2013) annual report on exchange rate arrangements, other managed arrangement are when the exchange rate is neither characterized by a fixed, floating, crawling peg nor crawl-like arrangement, but by frequent shifts in policies to influence export diversification through parallel market developments and other macroeconomic frameworks such as balance of payments and international reserves. In order to understand the monetary policy background of the African economies, this section discusses the exchange rate (nominal effective) arrangements and changes in the policy framework for each country.

3.3.2 Exchange Rate Policy in Algeria

Algeria's exchange rate was pegged to the U.S Dollar, prior to 1974, where the fixed exchange rate dominated exchange rate arrangements. From 1986 until 1988, the Algerian Dinar has constantly depreciated by approximately 31% due to severe oil shocks from the sale of its hydrocarbons (Koranchelin, 2005). The effects of a negative balance of payments in major export commodities led to a further depreciation of the exchange rate by approximately 25% from 1989 to 1991. The Dinar fell by approximately 3.6% annually from 1991 to 1994, equivalent to DA 24 per U.S Dollar. The Bank of Algeria (BoA) initiated an

³Artis and Ehrmann (2006) used the SVAR approach for the UK, Canada, Sweden and Denmark and found that the exchange is relevant in identification of the transmission mechanism of monetary policy shocks to the economy.

adjustment program in 1994 to stabilise the exchange rate.

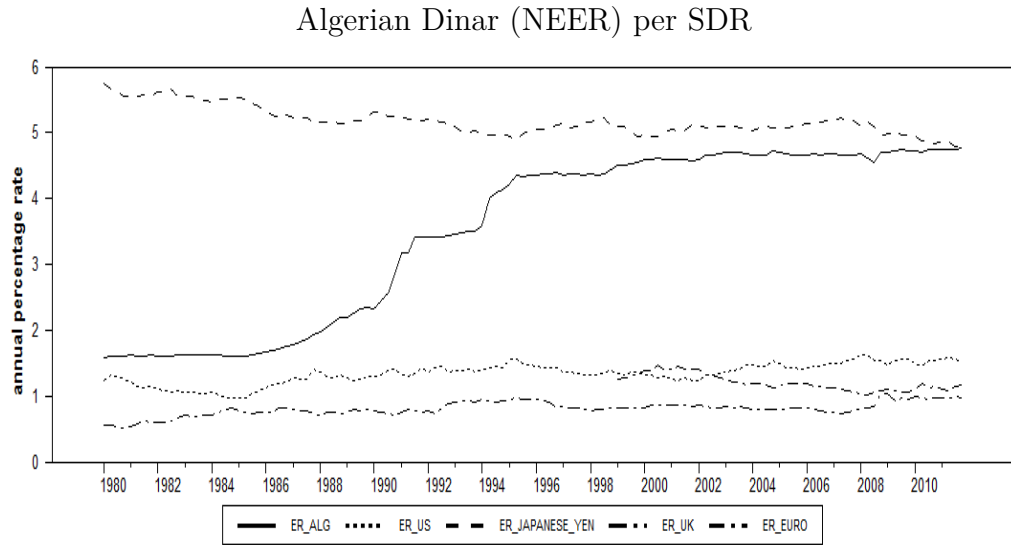


Figure 3.2: Trends in Algeria's Exchange Rate against Baskets of Currencies

In 1995, a managed floating exchange rate was introduced by the BoA, which led to an appreciation of the Dinar by approximately 20% through the period 1995 to 1998, followed by a depreciation by 13% until 2001. Since 1995, Algeria has maintained a stable exchange rate as the monetary policy is based on the exchange rate targeting. The Algerian Dinar is weighted against a basket of currencies of its major trading partners. These are the U.S Dollar, British Pound, the Euro and the Japanese Yen. Figure 3.2 shows that the Algerian Dinar has depreciated against the British Pound,⁴ the U.S Dollar and the Euro, following its introduction in 1999. The Algerian Dinar has constantly appreciated against the Japanese Yen, which is perhaps explained by the prolonged period of the Japanese recession.

3.3.3 Exchange Rate Management in Botswana

Botswana's exchange rate policy has undergone several changes which was pegged to the South African Rand before the Pula was introduced in 1976. This was to achieve a low inflation pass-through effect from South Africa, which is a major exporting country to the Southern African economies (Atta et al, 1995 and Buigut and Valev, 2006). The aim of exchange rate policy in Botswana has been to increase international competitiveness for its diamond exports. The Bank of Botswana (BoB) devalued the Pula by 7 percent in 2004 and 9 percent in 2005

⁴The British Pound Sterling is the most strongest currency in terms of purchasing power parity.

against the basket. These stylized facts for Botswana's exchange rate per special drawing rights (SDR) are illustrated in Figure 3.3 below.

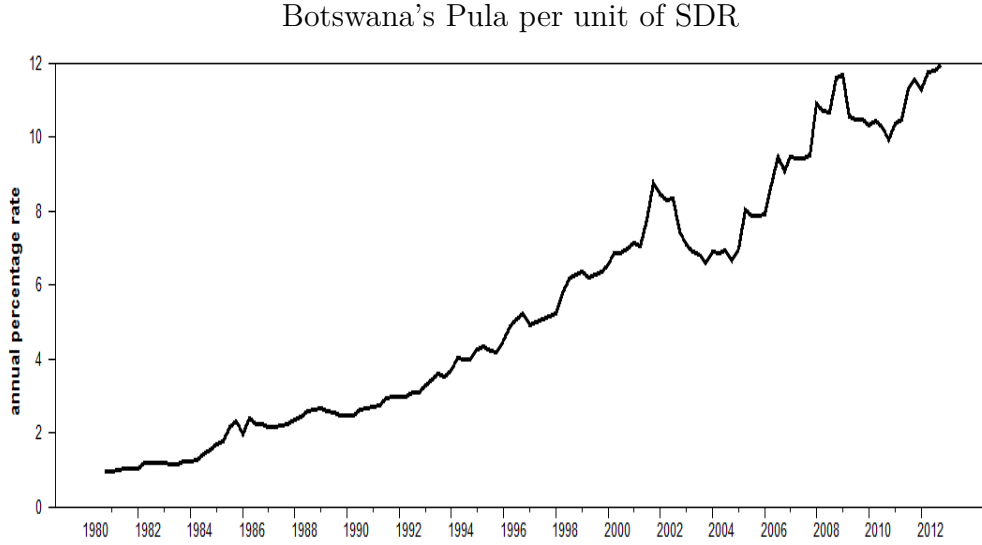


Figure 3.3: Botswana's Nominal Effective Exchange Rate

In May 2005, until recently, Botswana introduced a crawling band exchange rate regime (Iimi, 2006). The crawling band exchange rate mechanism implies that the nominal exchange rate of the Pula is adjusted in anticipation of inflation forecasts, to achieve price stability. The rate of crawl is based on the difference between the bank's inflation objective and the forecast inflation for Botswana's trading partners. The short-term nominal interest rate was used to influence changes in the exchange rate from 1993 to 2004.

3.3.4 Exchange Rate policy in Ghana

Like most African economies, Ghana adopted a fixed exchange rate regime pegged to the U.S Dollar following independence (in 1966) until 1986, following the introduction of the ERP involving trade liberalization. In 1986 the local currency (Cedi) was devalued to Cedi 90.00 per U.S\$1.00 from Cedi 2.75 per U.S\$1.00 in 1983 (Iossifov and Loukoianova, 2007). These large scale devaluations were attempts by the government to intervene in foreign exchanges following political elections that took place in 1983. By intervening directly in the market, led to structural rigidities in the economy for which stabilization measures by the IMF started in 1986 in order to increase domestic output and international competitiveness of Ghana's main export commodities. From the beginning of the early 2000's, the BoG adopted a managed float to control adjustments of the exchange rate.

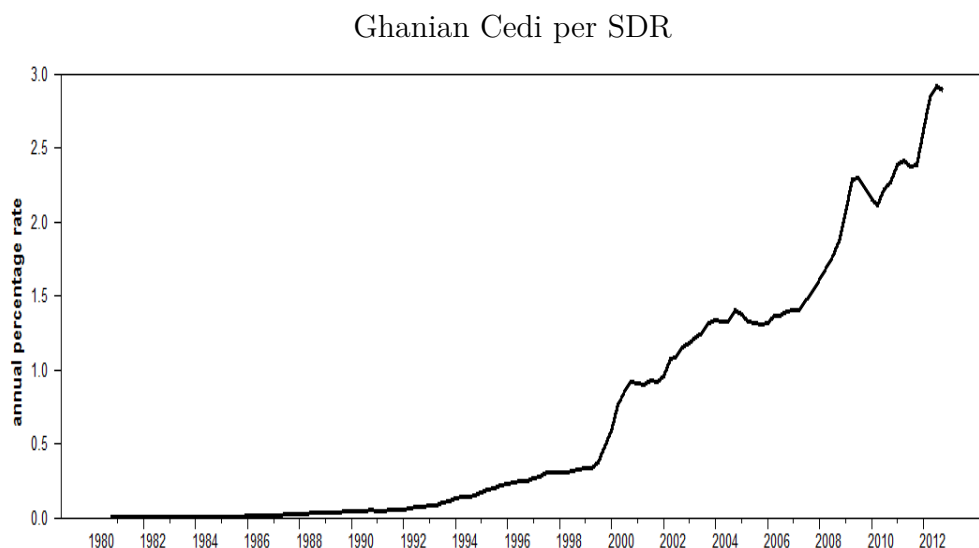


Figure 3.4: Evolution of Exchange Rate in Ghana

3.3.5 Kenya's Exchange Rate Policy

The exchange rate policy in Kenya has undergone various shifts, driven mostly by macroeconomic reforms such as the balance of payments crises. A crawling peg exchange rate regime was adopted from the early 1980's until the 1990's, accompanied by devaluation of the Kenyan Shilling as a result of exchange rate controls, which were SAP framework maintained until 1990. The period from 1990 to 1993 witnessed the implementation of a dual floating exchange rate to encourage flexibility in the determination of the exchange rate and the monetary targeting framework. While this accelerated money supply growth, inflation rose sharply following elections in 1992-93 (Berg et al, 2013).⁵

⁵See trends in inflation under overview of the monetary policy framework.

Kenyan Shilling per units of SDR

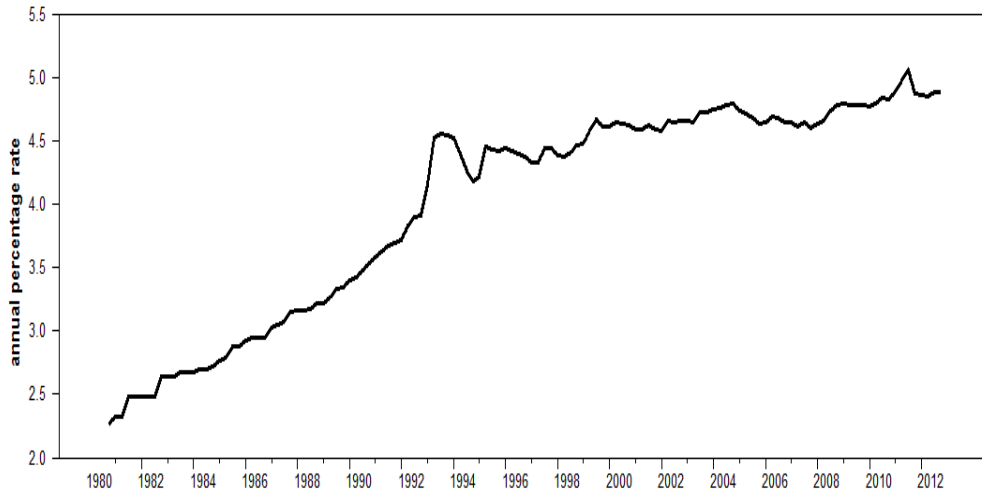


Figure 3.5: Evolution of Exchange Rate in Kenya

From 1993 until recently, the Central Bank of Kenya (CBK) intervened to manage the exchange rate. The IMF (2013), annual report on exchange rate arrangements and exchange restrictions, classified Kenya's exchange rate arrangement as floating. Monetary policy is conducted under *de jure* monetary targeting, and the use of interest rate to influence changes in the real economy such as output and inflation.

3.3.6 Exchange Rate Management in Nigeria

Exchange rate management in Nigeria can be classified under the pre and post 1986 periods. Before 1986, the Nigerian Naira was pegged to a basket of currencies, as a result of depreciation of the currency which began in 1981. A floating exchange rate regime was adopted from 1987 until 1993, following the introduction of SAP and stabilization programmes to improve efficiency in the foreign exchange market. The fixed exchange rate later came into being from 1994 until 1998 with the Naira exchanged for N22 per U.S\$1.00. The reason for adopting a fixed exchange rate was to regulate the economy, as inflation soared to 70 percent during the mid 1990's (see the monetary policy framework in Nigeria).

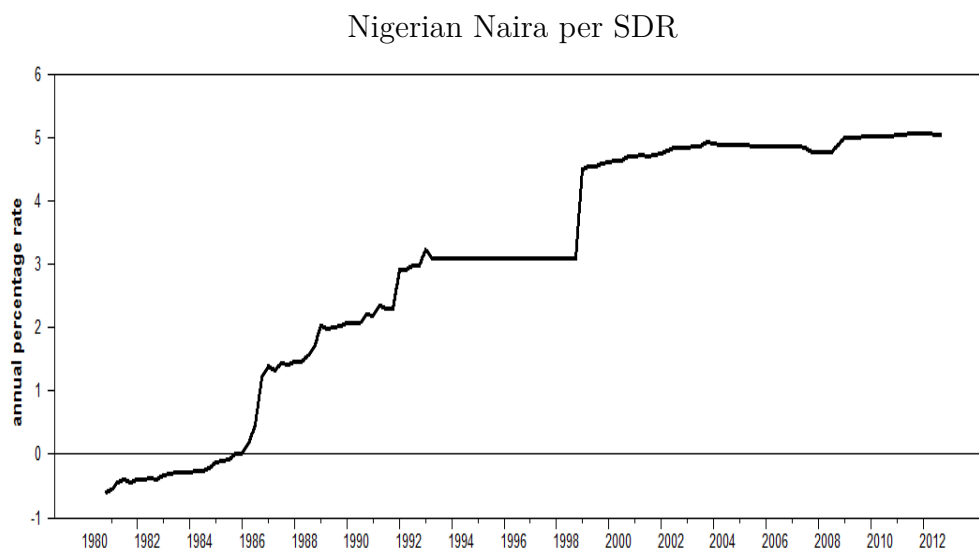


Figure 3.6: Exchange Rate Management in Nigeria

The exchange rate policy after 1998 could be classified as a managed float, in which the CBN intervenes to control the balance of payments and inflation (Slavov, 2013).

3.3.7 South Africa's Exchange Rate Policy

According to the IMF (2013) annual report on exchange arrangements, the exchange rate policy of South Africa can be classified as a floating system⁶ given that the primary objective of monetary policy is to target inflation. The South African Reserve Bank (SARB) allows market forces to determine the Rand in the foreign exchange market since the early 1980's following the introduction of market-based instruments (Akinboade et al, 2004). The Rand has experienced a significant depreciation since 1995 as compared to the deflationary periods between 1986 to 1993.

⁶Ahmad et al (2011) and Slavov (2013), studied exchange rate regimes in Sub-Saharan Africa and found that South Africa follows a floating exchange rate system.

South Africa's Rand per U.S Dollar

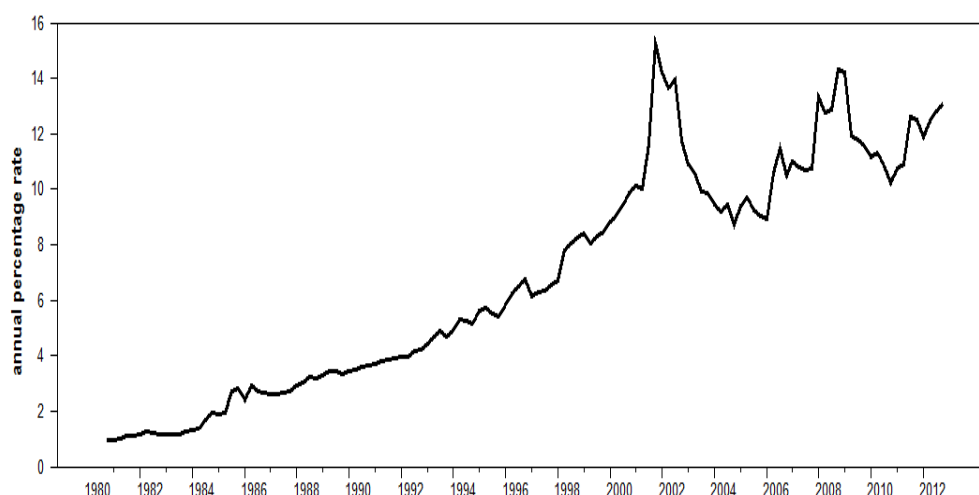


Figure 3.7: Evolution of Exchange Rate in South Africa

Between 2000 to 2002, the Rand depreciated continuously and in 2001 by approximately 15.3% against the U.S Dollar, which resulted from the turmoil of the September 11, 2001 U.S attack, given that the U.S is South Africa's main trading partner. It has been argued that the change in exchange regime from a dual exchange rate system until 1995 to a floating exchange rate system has exposed the South African economy to exchange rate shocks (Matemba, 2002). The policy response was inflation targeting of the rate of increase of the consumer price level to 3-6%, which was adopted by the SARB in 2000 (Bhundia and Gottschalk, 2003).

3.3.8 Exchange Rate Policy in Tunisia

The exchange rate policy in Tunisia has been to maintain a stable exchange rate against a basket of currencies. Tunisia embarked on SAP from 1983-1984.

Tunisia's NEER per SDR

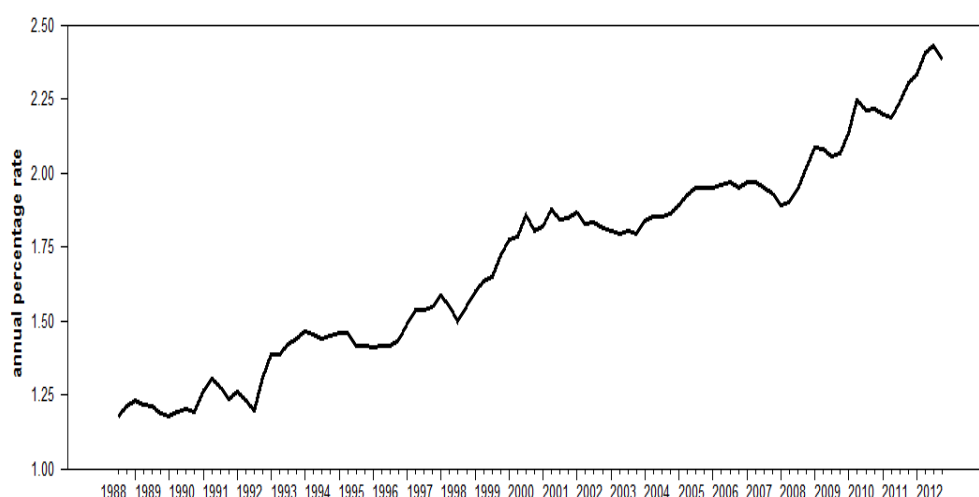


Figure 3.8: Trends in Tunisian Dinar

According to the IMF (2013) annual report on exchange arrangements and exchange restrictions, Tunisia's exchange rate management can be classified as a crawling peg, where the Central Bank of Tunisia (CBT) intervenes to minimise inflation pass-through between the Tunisian Dinar and that of its trading partners.

3.3.9 Uganda's Exchange Rate Policy

Prior to the 1980's the Ugandan Shilling was pegged to the U.S Dollar at the rate of Shs 7.14286 per U.S\$ 1.00. From 1981 until recently, Uganda adopted a floating exchange rate policy, coupled with a strong monetary targeting framework, initiated in 1993 until 2011 when inflation targeting lite (ITL)⁷ was introduced. This means that with a floating exchange rate regime, the Bank of Uganda (BoU) announces an inflation target to bring inflation to within single digits, but are not able to maintain the inflation target as the foremost policy objective due to low credibility (Stone, 2003). One can infer from this discussion that the exchange rate is central to monetary policy in Uganda.

⁷This is the process by which a central bank sets broad inflation targets, but low credibility hinders the prospects of achieving them due to domestic shocks, weak institutional frameworks and financial instability (Carare and Stone, 2006).

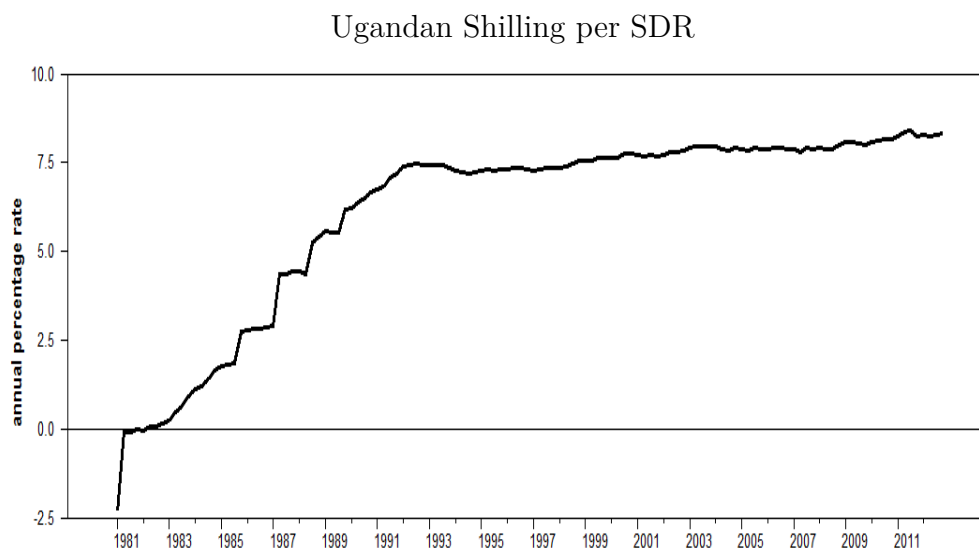


Figure 3.9: Movement in Uganda's Exchange Rate

Table 3.1 provides a summary of the exchange rate arrangements. De Jure is the central bank officially announced exchange rate regime, while De Facto represents the IMF identified exchange rate arrangements based on information by the central bank. Monetary policy is stronger with a floating exchange rate than a fixed exchange rate. This is because a fixed exchange rate exposes the economy to external shocks which are based on the inflation differentials from the currencies with which the local currency is pegged (Durevall and Sjo, 2012).

Table 3.1: Summary of Exchange Rate Arrangements

Country	Periods	De Jure Exchange Rate	De Facto Exchange rate
Algeria	1980:01-1994:04	Pegged to the basket	\pm
	1995:01-2012:04	Managed floating	
Botswana	1980:01-2005:04	Pegged to the basket	Crawling peg
	2005:04-2012:04	Crawling peg	
Ghana	1980:01-1986:04	Pegged to the U.S Dollar	Floating
	1986:04-1999:04	Managed floating	
	1999:04-2012:04	Managed floating	
Kenya	1980:01-1990:04	Pegged to the basket	Floating
	1990:04-1993:04	Dual floating	
	1993:04-2012:04	Floating	
Nigeria	1980:01-1986:04	Pegged to the basket	\pm
	1987:01-1993:04	Floating	
	1994:01-1998:04	Pegged to the U.S Dollar	
	1999:01-2012:04	Managed floating	
South Africa	1980:01-1993:04	Floating	Floating
	1994:01-2005:04	Floating	
	2005:04-2012:04	Floating	
Tunisia	1980:01-1998:04	Crawling peg	Crawl-like arrangement
	1999:01-2012:04	Crawling peg	
Uganda	1981:01-1993:04	Floating	Floating
	1994:01-1998:04	Floating	
	1999:01-2012:04	Floating	

Source: IMF (2013) and Ahmad et al (2011). \pm indicate other managed arrangement.

3.4 Overview of Monetary Policy

3.4.1 Introduction

With the exception of the currency unions⁸ or monetary integration, monetary policy has evolved steadily in most African economies, since the early 1990's. This mandate is evident in the central bank constitutions, where the main objectives of monetary policy include; controlled monetary growth, price and exchange rate stability. Monetary policy is mainly conducted by using the short-term nominal interest rate, as these economies have become more market oriented. The broad objective is to ensure that monetary policy is conducted so as to target inflation, increase output and support government policies (in terms of economic growth), although slight differences occur in the monetary policy framework for

⁸This is because the policy frameworks in a currency union in the African economies are concentrated around economic integration with fiscal policy dominance. The focus on monetary policy is much stronger where central banks are independent than in a monetary union lacking independence and the autonomy of policy decisions.

each country. This section describes an overview of monetary policy in the sample of African economies.

3.4.2 Monetary Policy in Algeria

The BoA was founded in 1962, to conduct monetary policy by maintaining a stable exchange rate. From its inception in 1962 until 2011, monetary policy targeted inflation to (4-4.5%) through the use of exchange rate in inflation targeting. Inflation remained stable, until 2012 when inflation soared to approximately 10%, affecting the conduct of monetary policy and the stability of the exchange rate which is the Algerian Dinar. According to Carare and Stone (2006), it is not clear whether Algeria is an inflation targeting country or not. This means Algeria can be classified as a non-inflation targeting economy, with a managed floating exchange rate used to stabilise changes in the economy.

Fig A: Inflation vs Main Policy Instruments in Algeria

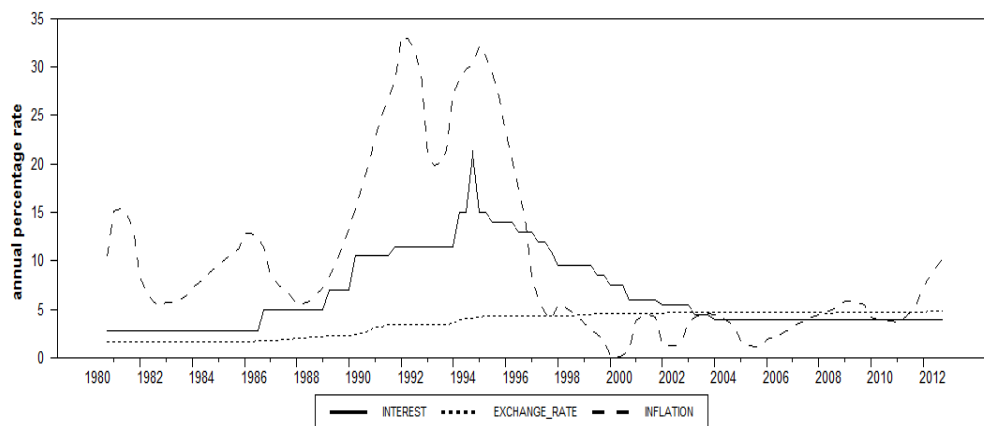


Fig B: Inflation and Commodity Price in Algeria

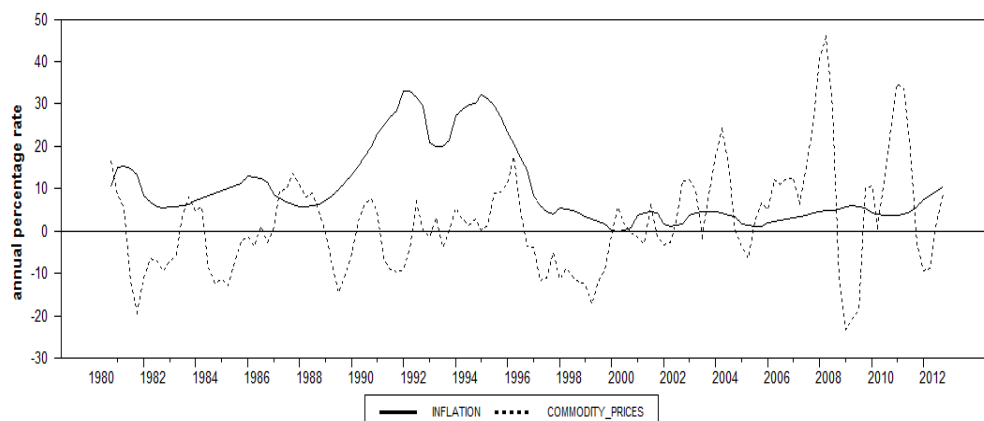


Figure 3.10: Evolution of Inflation and Exchange Rate in Algeria

Figure 3.10 shows that inflation fluctuated by 2-7% between 2004-2009, and then rose sharply to approximately 10% in 2012, partly explained by fluctuations

in commodities (food price inflation and the sales of hydrocarbons). The BoA then increased the required reserve rate in 2012, to reduce inflation (Naceur, 2013).

3.4.3 Monetary Policy in Botswana

Two policies have shaped the monetary policy framework in Botswana, since it was established in July 1975. These include the adjustment of the nominal effective exchange rate and adjustments to the policy rate in order to influence inflation. This dual strategy has been used by the BoB in order to maintain stability of the Botswanan Pula which is the exchange rate, following its introduction in 1976 and the use of interest rate to influence changes in aggregate demand. Price stability is the main objective of the BoB. Inflation targeting was formally introduced in 2008 by the BoB to target the rate of change of the CPI at 3-6%.

3.4.3.1 Historical Background of Monetary Policy

The South African Rand has been the major traded currency in Botswana since gaining its independence in 1966. Botswana maintained its membership of the Rand Monetary Area (RMA), with the following member countries; South Africa, Lesotho, Swaziland and Namibia (formerly known as South West Africa). This led to the establishment of the BoB in July 1975 to maintain stability of the exchange rate (introduced in August 23, 1976 and pegged to the U.S Dollar, until 1980), domestic interest rates and the regulation and supervision of financial institutions. South Africa introduced a managed floating exchange rate regime in 1979, as a result of the collapse of the Bretton Woods system of fixed exchange rate.

3.4.3.2 Stylized Facts of the Exchange Rate

Paradoxically, the South African Rand appreciated (against the U.S Dollar) due to increased gold prices, while the Pula depreciated against the Rand as a result of the inflation pass-through effect from South Africa (Atta et al, 1995). These stylized facts are shown in panel A and Panel B of Figure 3.11.

Fig 3.11a: Botswana vs South Africa's Inflation Rates

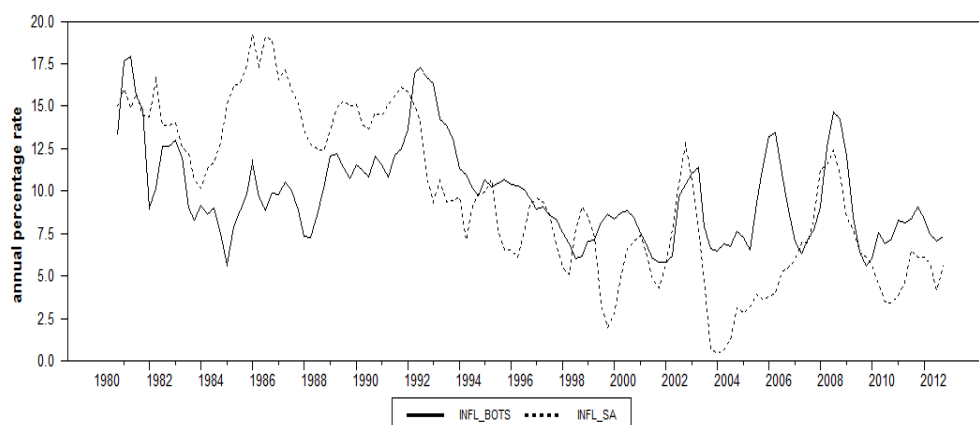


Fig 3.11b: NEER per SDR for Botswana and South Africa

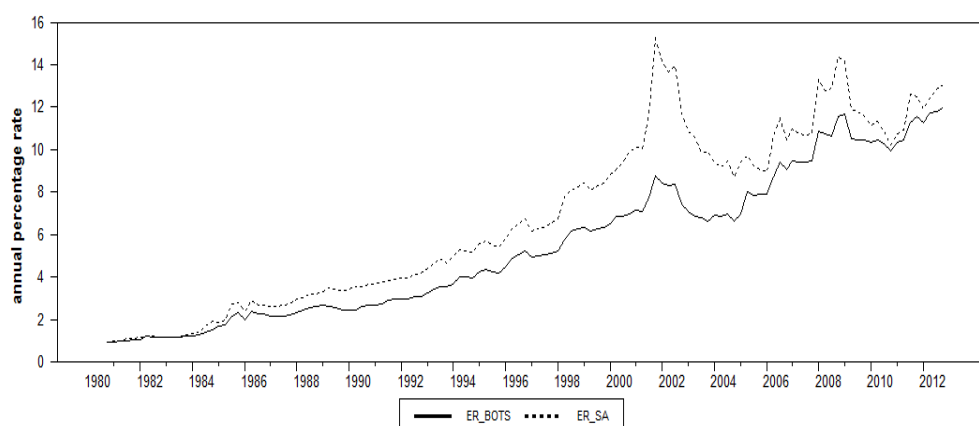


Figure 3.11: Inflation and Exchange Rates in Botswana and South Africa between 1980:01 - 2012:04

The Pula was further devalued in May 1982, following the aftermath of persistent oil shocks in the late 1970's. The Rand equally was devalued by 5% to 15% from July 1984 to January 1985 due to economic sanctions over the Apartheid regime in South Africa. Inspection of the graphs suggests that the Pula appreciated by 0.4% against the South African Rand during the period 2011 to 2012.

3.4.4 Monetary Policy in Ghana

3.4.4.1 Brief Historical and Institutional Background

The BoG was established on March 4, 1957, under BoG, ordinance No. 34 of 1957 in light of political independence that emerged within the same year (BoG Quarterly Bulletin, 2013). Since its inception in 1957, many legislative changes were enacted in 1963 (Act 182), 1965 (Act 282) and included BoG Law in 1992 (Act 291) to consolidate monetary policy and banking reforms. In particular, liberalization of financial and banking services as well as credit reforms (where

direct monetary instruments were used). Monetary targeting later became operational from the period 1992-2002.

The BoG currently operates under Act (612) of 2002 which is an amendment of the original Act, to grant full responsibility (both operational and instrument independence) to the BoG monetary policy committee to set interest rate, in order to control inflation and increase output growth (Afari, 2005). The monetary policy committee comprises 7 members (the Governor, two Deputy Governors, two internal Directors⁹ and two external members appointed by the Ministry of Finance, to ensure transparency and effectiveness in the conduct of monetary policy.

3.4.4.2 The conduct of Monetary Policy in Ghana

The monetary policy rate reflects a mark-up for other short-term interest rates in the interbank market (money, credit and financial markets). In Ghana, inflation targeting was initiated in 2002 to replace monetary targeting which was implemented from 1992 to 2002 (Kovanen, 2011). In July 2007, Ghana embarked on a currency re-denomination from Cedi to the new currency, the Ghanaian Cedi. The transfer rate was one Ghanaian Cedi for every 10,000 cedis was supported by the BoG. The current monetary policy stance of the BoG, is to target the annual rate of change of the CPI to 9% but allowing for 2% above or below the targeted level of inflation. This is achieved by raising the key lending rate (currently at 16%) above inflation to underpin monetary policy tightening. Figure 3.12 presents these stylized facts. Inspection of the time-series plot suggests that the adoption of inflation targeting may be responsible for the reduction in inflation since 2002.

⁹For research and development as well as banking and credit services (BoG Monetary Policy Report, 2013).

Fig: Inflation vs Interest Rate

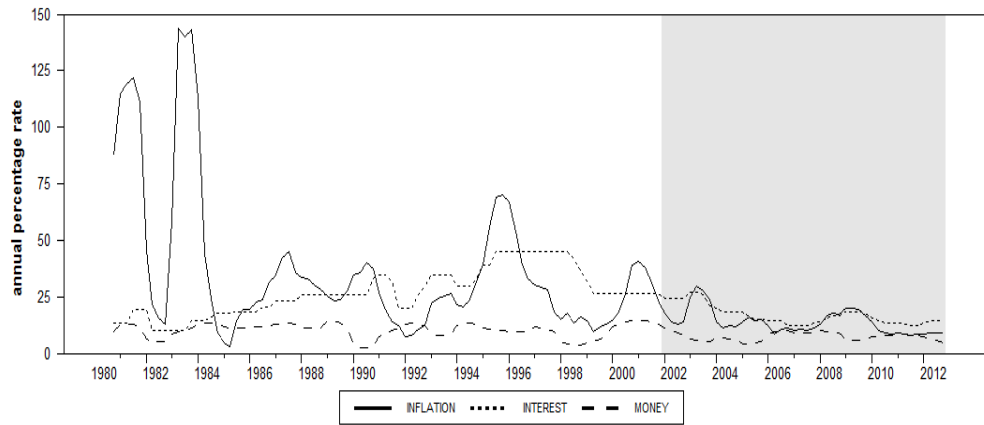


Figure 3.12: Ghana Inflation, Interest Rate and Money Growth: 1980:01 - 2012:04

3.4.5 Monetary Policy in Kenya

3.4.5.1 Historical Background

The CBK was established in 1966, following the Central Bank Act of 1966 (by parliament) to implement monetary policy, maintain price stability, as well as the exchange rate and liquidity management (Cheng, 2006). The aim was to have an independent monetary policy from other East African States, formerly controlled by the East Africa Currency Board with Kenya being the largest economy, which later collapsed in 1960. The period from the early 1990's was characterized by deregulation of the economy by removing interest rate controls and the introduction of a flexible exchange rate (Rotich et al, 2007). Hence, the CBK Act was amended in 1996 to allow operational autonomy and the targeting of monetary aggregates, following the post liberalization period (1997 to 2006). The monetary policy committee in Kenya is an integral part of the institutional arrangements to enable transparency and communications of policy actions. These stylized facts for Kenyan monetary policy are illustrated in Figure 3.13.

Fig: Stylized facts of an evolution of monetary policy in Kenya

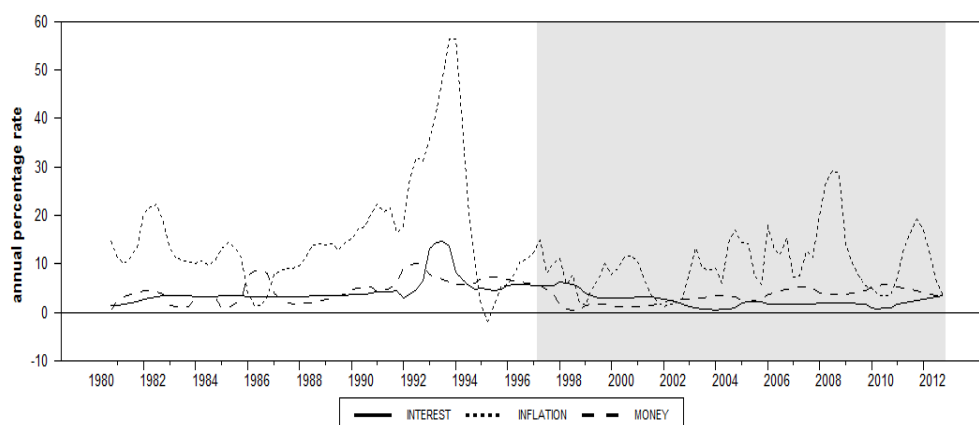


Figure 3.13: Monetary policy instruments in Kenya 1980:01 - 2012:04

Prior to April 2008, the monetary policy advisory committee (MPAC) formulated monetary policy in Kenya, in which price stability and the growth of the money supply were the main objectives. The CBK created a monetary policy committee on April 30th, 2008 (to replace MPAC) consisting of 9 members (Governor and Deputy Governor, 2 internal members, 4 external members and a member representative of the Ministry of Finance). The creation of a monetary policy committee was to initially target inflation within 5%, but allowing for 2.5% below or above the target. Article 231 of the new constitution in August 27, 2010 gave the CBK responsibility for formulating monetary policy, consistent with the economic objectives of the government, aimed at targeting long-term inflation to below 5%. This is to ensure that private sector expectations are anchored (through annual survey questionnaires to commercial banks, CBK, 2013). The bank uses the key policy rate, which is the monetary policy rate in order to influence other rates in the money market. Key policy instruments include; the short-term nominal interest rate initiated in 1997 (through open market operations) while a fixed exchange rate was used prior to 1997 as a monetary policy instrument.

In Kenya, inflation rose above 50% during the period 1993-94 following a series of negative supply shocks such as droughts (Durevall and Ndung'u, 2001). Restrictive monetary policy is adopted to reduce the variance of inflation, caused by adverse supply shocks such as through commodity price (Cheng, 2006). According to the IMF (2014) regional economic outlook, domestic inflation in Kenya are largely attributed to negative supply shocks from international food prices.

3.4.6 Monetary Policy in Nigeria

3.4.6.1 Institutional Framework and Policy Instruments

The CBN was founded in 1958, following the CBN Act, 1958 to promote price stability and the stability of the financial system (Chuku, 2009). Two periods of monetary policy framework can be ascertained in Nigeria. The first period, of direct control (1960 to 1986), where monetary policy was passive, relying on, selective sectoral credit allocation (credit ceilings) and price controls. The use of market based instruments such as interest rates was ineffective because of underdeveloped financial markets¹⁰ and weak financial structures, resulting from instability of the money demand function and depreciation of the exchange rate. Hence the responsibility and supervision was shared between the CBN and Ministry of Finance until 1991 (CBN Act in 1991), when full instrument and goal autonomy¹¹ was granted to the CBN, under the Banking reform Act of 1969.

Monetary policy since July 1986 became effective, with the introduction of SAP. This period emphasises the role of market based instruments such as open market operations in 1993 through to repurchase agreement and a minimum discount rate to influence the cost of funds and economic activity. Monetary aggregates in combination with exchange rate targeting and the short-term interest rate were used to stabilise prices and increase output growth.¹² The used of different policy instruments was a common feature to most African economies central bank's, including the CBN (Saxegaard, 2006). The 1997 Act (which brought the CBN under supervision), was amended in 1998 (Decree No. 37) to provide operational autonomy to the Bank to conduct monetary policy (Dada, 2011).

The monetary policy committee consists of the Governor, four Deputy Governors in charge of (corporate services, economic policy, financial system stability and operations) and six non-executive members, including a representative from the Ministry of Finance and Accountant-General of the Banking Federation (Annual report, 2011). This is to ensure efficiency in the conduct of monetary policy, financial stability and accountability. The CBN in 2007 announced the intention to switch from monetary targeting to inflation targeting to maintain price sta-

¹⁰Bernanke et al (1999) and Mishkin (2007b) argues on the role of credit expansion in propagating monetary transmission mechanism.

¹¹Contrary to the Bank of Japan where monetary policy decisions were made with the Ministry of Finance, until 1998. And full autonomy was not granted to the Bank of England to set interest rate until 1997 (Mishkin, 2007b).

¹²Short-term nominal interest rate influence economic activity to a larger extent than other monetary policy instruments (Bernanke and Mihov, 1998) and when an economy moved to a market-oriented structure (Zhang, 2009).

bility. The CBN Act of 2007 granted autonomy to the CBN to set interest rate and discretion to limit its credit to the government (as a lender of last resort) to finance the fiscal deficit (Dada, 2011).

3.4.6.2 Stylized Facts of Monetary Policy in Nigeria

Monetary policy instruments from post 1986 include; the exchange rate, money supply and the nominal interest rate. Non-policy variables are the CPI and real GDP. Figure 3.14 shows a graphical analysis of inflation, interest rate and money growth in Nigeria.

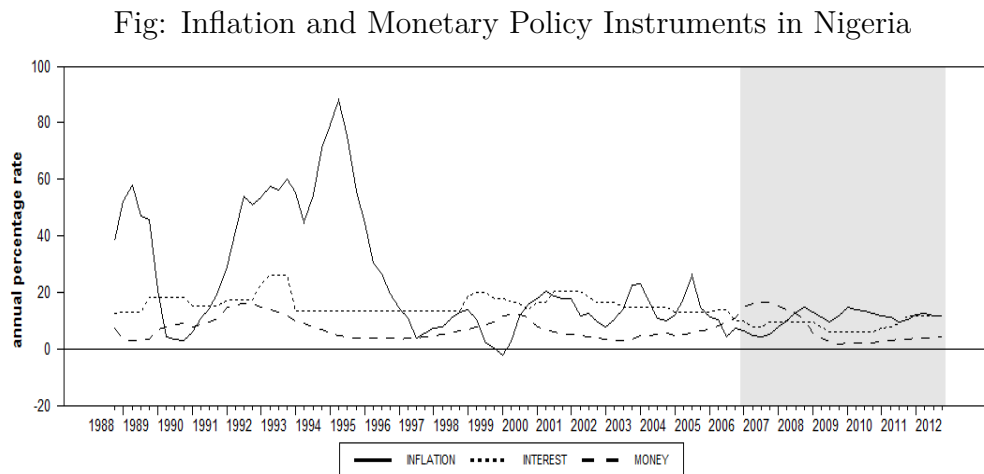


Figure 3.14: Inflation, Short-term nominal interest rate and Money growth in Nigeria

Nigeria was no exception to experiencing high inflation (above 70.0%) that affected most economies in the 1980's and the early to mid 1990's, mainly attributed to global commodity price hikes and the macroeconomic reform policies which were initiated by the IMF and the World Bank. Although changes in consumer prices rose to double digits, growth rates averaged about 3.6% in 2007 (Dada, 2011). The implementation of interest rate targeting in 2007 coincided with a fall in inflation to 8.4%.

3.4.7 Monetary Policy in South Africa

The SARB was established on 30th June 1921, following the Currency and Banking Act No 31 of 1920. The SARB Act of 1991 entrusted it with operational independence and the 1996 Act gave full autonomy to the SARB to implement monetary policy. The monetary policy committee consists of the Governor, three Deputy Governors and three Advisors to the Governor (including the Head of

Research and Economic policy), to set interest rate and to influence other rates in the money and interbank market (SARB Quarterly Bulletin, 2013).

3.4.7.1 The Conduct of Monetary Policy Framework

Maintaining price stability¹³ is the main objective of monetary policy, under the SARB Act of 1989 (Act No 90), as well as the Constitution Act of 1996 (Act No 8). Inflation targeting was formally introduced in February 2000 by targeting the rate of change of the CPI to (3-6)%, following the introduction of the repurchase rate¹⁴ in 1998 (Kabundi and Schaling, 2013). Figure 3.15 illustrates movements in the repurchase rate and the short-term three months treasury bills rate against inflation from the period 1980:01 - 2012:04. Two conclusions can be documented from the graphical analysis. Firstly, the monetary policy rate, can be proxied by the three months treasury bills rate as the two series move together. Secondly monetary policy has been contractionary, by raising short-term nominal interest rate in response to inflation. Inflation returned to single-digit in 1993, which led to the use of interest rate in the years following inflation targeting. By the second quarter of 1998, averaged inflation had fallen to 5.261% (see Figure 3.15 below). This is because inflation targeting is the main objective of the SARB since it was launched in 2000 (Akinboade et al, 2004).

Fig: Inflation vs Interest Rates

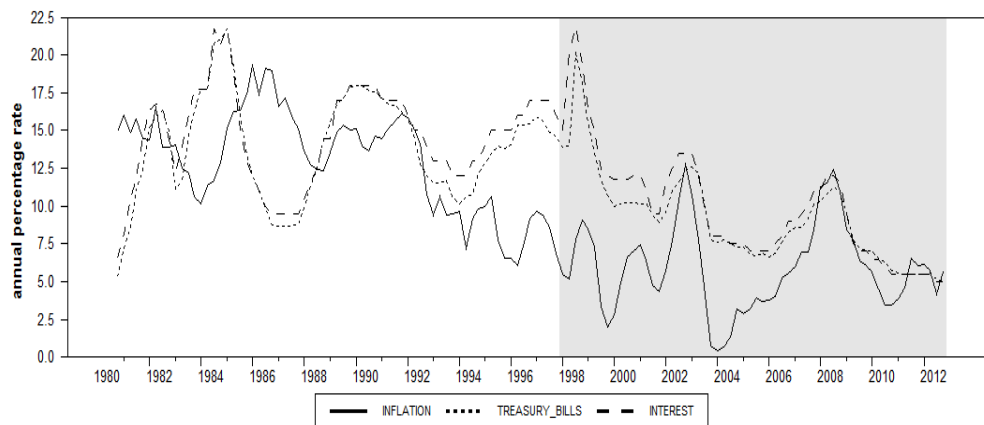


Figure 3.15: Interest Rates and Inflation in South Africa

The main reasons for adopting the inflation targeting framework includes; to reduce inflation, which soared to above 15% in the 1980's during the periods of monetary targeting which was introduced in the fourth quarter of 1985 through

¹³Other objectives include exchange rate and financial stability as well as the rate of growth of output.

¹⁴This is the rate at which the SARB lend funds to private sector banks.

the early 1990's and to determine the transmission mechanism of monetary policy shocks to the real economy (Van de Merwe, 2004). This aim was to determine the appropriate policy response of the effectiveness of interest rate in influencing aggregate demand and therefore inflation. South Africa follows the fully-fledged inflation targeting framework of the rate of the CPI by 6% (Carare and Stone, 2006). Current inflation, measured as the year-on-year rate of change of the CPI is 5.3% (SARB Quarterly Bulletin, 2013).

Efforts were made to reduce inflation in 1990 (through informal inflation targeting). This took the form of exchange rate¹⁵ targeting from 1960 to 1998, and the used of monetary aggregates as the main policy instruments, while interest rate played an intermediary role (Smal and Jager, 2001). The broad money supply is the quarter-to-quarter rate of growth in M3, which grew in the second quarter of 2013, due to strong credit expansion (in loans and advances) by 13.1% for the period. These stylized facts are depicted in Figure 3.16, showing growth in the real economy and interest rate.

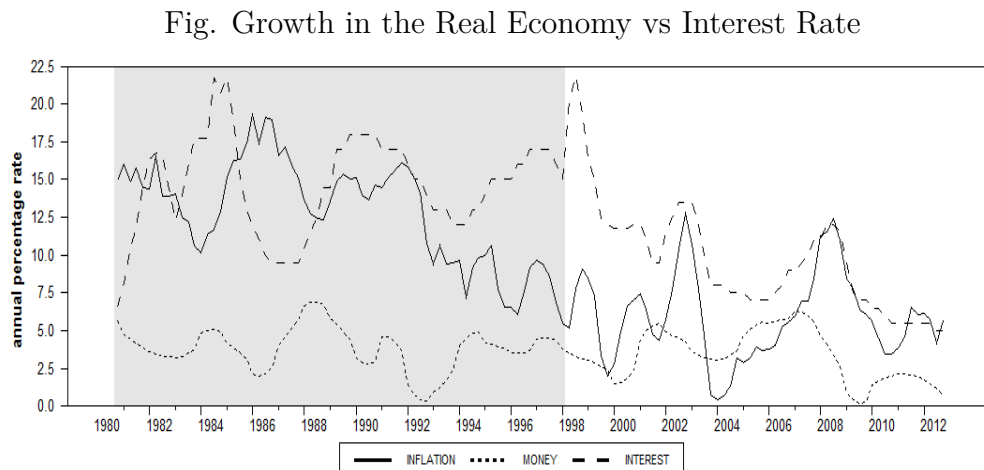


Figure 3.16: Money supply growth, Inflation and Interest Rate in South Africa

Other concerns included rising unemployment, 16% pre-apartheid and 20% post-apartheid (Amusa et al, 2013). This resulted in the fall in output growth and the depreciation of the exchange rate (the Rand) against the U.S Dollar by approximately 8.4% due to global imbalances (as the Japanese Yen and UK Pound Sterling fluctuates against the U.S dollar) and also due to weaknesses in the domestic economy. In answering the question of monetary policy effectiveness in South Africa, one should consider the pre and post 1998 sample period in which

¹⁵The nominal effective exchange rate, expressed as units of local currency per SDR. This includes a basket of currencies, mostly dominated by the U.S Dollar, the Euro, British Pound Sterling and the Japanese Yen.

interest rate was introduced and followed by inflation targeting in 2000.

3.4.8 Monetary Policy in Tunisia

Enactment of Act No (58-90) created the CBT in 1958, just six months after Tunisia's independence to formulate monetary policy. The Tunisian Dinar (crawling exchange rate) was the main policy instrument, until 1987 where the intermediary objective was to target monetary aggregates (Treichel, 1997). Price stability is seen in terms of maintaining a constant rate of growth of the money supply to 2% (see Figure 3.17 below). Tunisia has never targeted inflation for monetary policy framework, but uses the money supply to stabilise the economy.

Fig: Evolution of monetary policy instruments

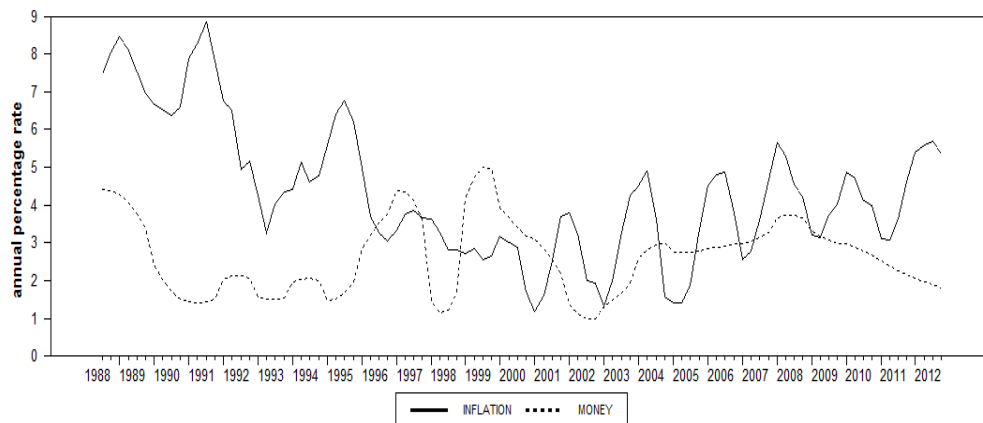


Figure 3.17: Main Monetary Policy Instruments in Tunisia

In 1999, the broad money aggregate (M3) was targeted, instead of M2. Article 33 of the May 2006 Central Bank Law enforces instrument independence under which the bank operates (Chailloux et al, 2009). It is often debated whether moving away from monetary targeting to inflation targeting would improve the conduct of monetary policy in Tunisia. This is because the monetary targeting strategy is the main instrument used by the CBT since the late 1980's until recently to minimise the variance of inflation and increase output growth.

3.4.9 Monetary Policy in Uganda

The BoU was established in August 15, 1966 with the aim of maintaining price stability and development of the financial system. The BoU Act 2000 established the framework for the conduct of monetary policy, including supervision and regulation of financial services. Like most African economies, the BoU maintained a fixed exchange rate from the 1960's to the 1970's. But asymmetric shocks caused

by oil prices in the late 1970's prompted the BoU to adopt a managed floating exchange rate (Opolot and Kyeyune, 2012).

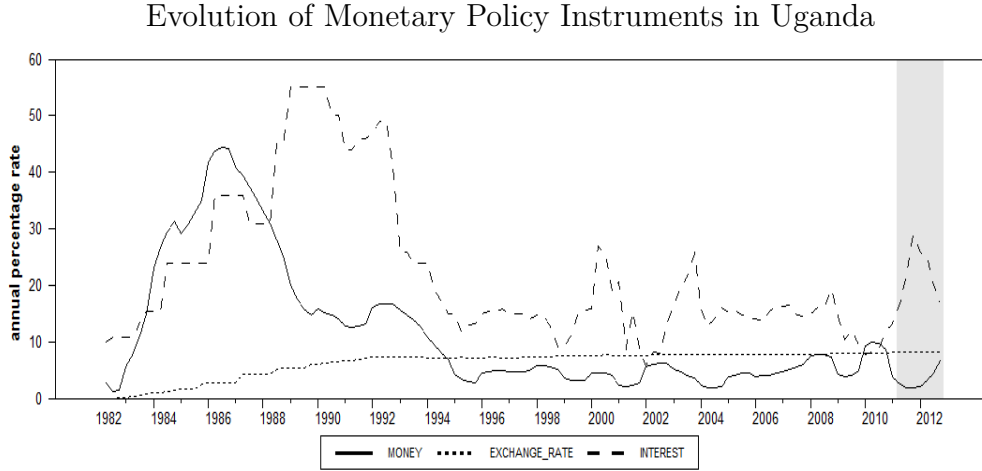


Figure 3.18: Growth rate of Money, Interest Rate and Exchange Rate in Uganda

The BoU Act (1993) introduced monetary targeting under the control of the reserve monetary programme (RMP) between 1993 and the fourth quarter of 2010. The aim is to maintain stability of monetary aggregates; and exchange rate and with inflation target of 5%. ITL was introduced in July 2011 because of instability in the money demand function as changes in money supply affected inflation (Opolot and Kyeyune, 2012). The aim was to use the interest rate as the main policy instrument rather than monetary aggregates. Berg et al (2013) ascertained that ITL is more transparent and has induced a fall in inflation. The current bank rate is set at 11.5%. According to the IMF (2014) regional economic outlook, Uganda is transitioning towards an inflation targeting, which is otherwise called ITL. Also see Carare and Stone (2006).

3.5 Summary of the Monetary Policy Regimes

Tables 3.2 and 3.3 present a summary of the monetary policy regimes in the African economies including the periods when inflation targeting frameworks were introduced. The results derived from the policy background suggests that since the mid 1980's, the African economies have implemented an comprehensive monetary policy framework which consisted of an exchange rate targeting, monetary targeting and more recently inflation targeting. It shows that Algeria and Tunisia are the only two non-inflation targeting emerging economies within the sample of the African economies considered. Their central banks have targeted the exchange rate and growth rate in the money supply respectively (see Table 3.3). Beginning from the early 2000's inflation targeting has been the main monetary

policy framework in the African economies by targeting the rate of increase of the CPI. It is not clear whether Nigeria is an inflation targeting country, although interest rate targeting was introduced in 2007 by the CBN.

In the monetary targeting economies like Nigeria and Tunisia, the interest rate is used as a complement to the growth rate in the money supply. The aim is to allow for greater flexibility in the monetary policy framework. ITL in Kenya and Uganda suggests that they are transitioning towards market-based instruments, following their introduction in 2008 and 2011 respectively (IMF, 2014). Unlike Uganda, Kenya has not formally introduced inflation targeting, although the creation of a monetary policy committee in 2008 gave the CBK independence to conduct monetary policy, with price stability as the main objective. It is currently debatable whether Kenya would benefit from an inflation targeting framework in terms of reducing inflation to single digits. Therefore, the use of hybrid ITL in Kenya as the term implies, considers the importance of the exchange rate in an inflation targeting framework (IMF, 2014 regional economic outlook). Roger et al (2009) argue that hybrid ITL is important for emerging and small open economies in order to consider the importance of the exchange rate in the monetary policy framework. The interpretation of hybrid ITL in Kenya suggests that the monetary authorities reacted gradually to shocks from macroeconomic variables. The inflation target in Ghana and Kenya is conducted with an allowable margin of 2.00% and 2.50% outside the inflation target. The conclusion is that both Ghana and Kenya practises a flexible inflation targeting framework.

Table 3.2: Year of Inflation Targeting

Country	Year	Monetary Policy Framework
Algeria	×	Non-Inflation targeting
Botswana	2008	Inflation targeting
Ghana	2002	Inflation targeting
Kenya	√	Hybrid Inflation targeting lite
Nigeria	2007	Not clear
South Africa	2000	Inflation targeting
Tunisia	×	Non-inflation targeting
Uganda	2011	Inflation targeting lite

Note: × = non-inflation targeting, √ = transitioning

Table 3.3: Summary of the Monetary Policy Regimes

Country	De Facto Monetary Regime	Policy Target	Target rate (%)
Algeria	Exchange rate targeting	Exchange rate stability	Algerian Dinar
Botswana	Inflation targeting	CPI	3-6
Ghana	Inflation targeting	CPI	9 ± 2
Kenya	Hybrid inflation targeting lite	CPI	5 ± 2.5
Nigeria	Monetary targeting	CPI	6-9
South Africa	Inflation targeting	CPI	3-6
Tunisia	Monetary targeting	Money supply	2
Uganda	Inflation targeting lite	CPI	5

Source: Central Bank News Inflation Targets Table for 2014

3.6 Policy Implications of Inflation Targeting in Ghana and South Africa

Before concluding on the monetary policy frameworks of the African economies, this section discusses the implications of inflation targeting on the variance of inflation in Ghana and South Africa. These countries are selected because their central banks had targeted inflation since the early 2000's, in comparison with the other African economies, where inflation targeting has been recently adopted. This means the results obtained may give a better understanding about improvements in macroeconomic policies such the inflation targeting framework in monetary policy for the African economies. The main objective is to determine whether the variance of inflation has reduced following years after adopting the inflation targeting framework. These results for Ghana and South Africa are reported in Tables 3.4 and 3.5 for inflation, the output gap and the interest rate, using quarterly data from 1980Q1 to 2012Q4 obtained from the IFS of the IMF.¹⁶

Table 3.4: Ghana inflation, output gap and interest rate in the pre-targeting and post-targeting inflation periods.

Variable	Regimes	Mean	σ	Median	Min	Max
Inflation	pre	37.688	32.469	27.141	3.183	143.974
	post	14.132	5.301	12.887	8.405	29.772
Output gap	pre	-0.001	0.121	0.014	-0.381	0.194
	post	-0.002	0.040	0.009	-0.084	0.064
Interest rate	pre	26.721	10.359	26.000	10.500	45.00
	post	17.153	4.364	15.750	12.500	27.500

Note: pre-targeting (80Q1 - 01Q4) and post-targeting (02Q1 - 12Q4)

Min & Max = minimum and maximum values of the series.

¹⁶See Chapter 4 for the sources and the definitions of the data.

Table 3.5: South Africa inflation, output gap and interest rate in the pre-targeting and post-targeting inflation periods.

Variable	Regimes	Mean	σ	Median	Min	Max
Inflation	pre	12.256	3.800	13.080	1.956	19.250
	post	5.873	2.918	5.679	0.437	12.754
Output gap	pre	0.001	0.019	0.003	-0.039	0.045
	post	0.000	0.012	0.000	-0.022	0.029
Interest rate	pre	14.454	3.723	15.000	4.780	21.850
	post	8.831	2.601	8.000	5.000	13.500

Note: pre-targeting (80Q1 - 99Q4) and post-targeting (00Q1 - 12Q4)
Min & Max = minimum and maximum values of the series.

The analysis shows that inflation targeting has reduced the variance of inflation in both countries (shown by σ which is the standard deviation, SD). Inflation returned to single-digits in South Africa in the post inflation targeting periods but the fall in inflation in Ghana in the post inflation targeting period reduced at a slower rate. This may be explained by the high inflation in the pre-inflation targeting periods caused by loose monetary policy. These results suggest that the main monetary policy objective for the African economies is inflation targeting. The output gap has fallen due to restrictive monetary policy as in the Taylor (1993) rule principle, and is also partly explained by recessionary conditions that prevailed under Apartheid in South Africa, while for Ghana this may be due to the macroeconomic policies involving SAP.

3.7 Conclusion

The purpose and motivation of this chapter was to discuss policy backgrounds of the African economies, aimed at examining the evolution of the exchange rate and monetary policy frameworks. Despite the resurgence of macroeconomic reforms (such as SAP and stabilization programmes) and institutional policies in African economies which were enacted in the late 1980's to increase domestic output, economic growth was only a partial success due to persistent oil and commodity price shocks and changes in policy measures (IMF, Quarterly Bulletin, 2013). This is because of a high inflation rate (above 100% in the case of Ghana), persistent negative GDP growth and a steady increase in trade and fiscal deficits in the period between the 1970's and the early 1980's, similar to most Sub-Saharan African economies.¹⁷

¹⁷The African economies and the Emerging market economies are now the fastest growing economies (in terms of real GDP growth) in the World.

Monetary policy in African economies became effective in the mid 1990's (post liberalization period) when the interest rate became the conventional instrument of monetary policy, while maintaining monetary aggregates and the stability of the exchange rate.¹⁸ Therefore, while the period from the 1970's to the 1980's is considered as the "lost decade", monetary policy is now actively involved in inflation targeting and to ensure that the volatility of the output gap is low (Durevall et al, 2013). The analyses from this chapter shows that monetary policy has evolved steadily in the African economies. This mandate is reflected in the central bank constitutions, where the main objectives of monetary policy include; price and exchange rate stability and controlled money growth. Evidence in Botswana suggests that monetary policy has targeted inflation at 4-6% and 3-6% from 2002 and 2008 and South Africa, 3-6%. The current fall in inflation in Botswana to 5%, with a medium-term inflation target of 3-6% indicates a strong monetary policy framework to anchor inflation expectations. Monetary policy in Tunisia has targeted the rate of growth in the money supply by 2%.

The contributions of this chapter to the thesis are four fold. Firstly, the exchange rate arrangements of the sampled economies reflects the institutional frameworks (SAP and stabilization programmes) initiated in the mid 1980's to improve macroeconomic policies and domestic competitiveness. Secondly, the data captures the stylized facts of an evolution in monetary policy in these economies as emphasis is made on reducing inflation and deviations from output growth. Thirdly, the chapter has identified the monetary policy regimes in the African economies which can be classified in terms of inflation targeting and non-inflation targeting emerging African economies. Finally, the adoption of inflation targeting has reduced the variance of inflation in the African economies which is indicative of a strong monetary policy framework. Following the post liberalization period, the interest rate became the conventional instrument of monetary policy as the African economies have become more market oriented, with functionally developed financial markets.

¹⁸This is consistent with the monetary policy framework of most developed economies, such as the Bank of England, the Bank of Japan and the Bank of Canada, where full responsibility to set interest rate and operational and goal independence was not granted until 1997 and 1998 respectively, while the latter has less goal independence (Mishkin, 2007b).

Chapter 4

Data Analysis and Testing for Stationarity

4.1 Introduction

This chapter focuses on the analysis of the data and the issue of stationarity. It discusses the data (sources and definition) used in the empirical analysis and offers a contribution in modelling structural breaks within unit root tests in monetary policy. The aim is to determine whether the data coincides with the host of institutional policies and macroeconomic adjustments such as SAP and stabilization programmes when modelling the monetary policy frameworks for the selected African economies. The Augmented Dickey-Fuller (1979, 1981) (ADF) and Phillips-Perron (1988) (PP) tests for a unit root as against the Kwiatkowski et al (1992) (KPSS) test for the null of stationarity are used to determine the time-series properties of the variables. The low power and size distortions of unit root tests have often come under attack in recent years especially with regard to structural breaks. Perron (1989) argues that failure to account for structural breaks in unit root tests reduces the probability of rejecting a false unit root null hypothesis. To circumvent this problem, this chapter incorporates the LS two breaks minimum LM unit root test, which is more plausible to the Lumsdaine and Papell (1997) test for detecting multiple structural breaks tests. Structural break points were endogenously determined from the data. This is to eliminate bias that may rise in an attempt to exogenously determine the break dates. The LS test is also valid in that it avoids spurious rejections¹ and bias, which is often considered as the main limitation with the ADF and PP unit root tests.

The rest of the chapter is organized as follows. Proceeding from the introduc-

¹Spurious rejection is the tendency that a stationary series that is subject to structural breaks may appear non-stationary, as it is the case with the ADF test.

tion, section 4.2 describes the data, by defining its sources and brief description of the variables used in the empirical analysis. Section 4.3 explains the sectoral components analysis of the African economies, to determined the relative contribution of the GDP and rationale for sample selection. Section 4.4 presents the methodology of unit root tests. This is followed by endogenous structural break tests in section 4.5. Section 4.6 analyses unit root test results together with the two - breaks minimum LM unit root test results in section 4.7. The analysis of structural breaks is in section 4.8 and section 4.9 highlights sensitivity analysis. Finally, section 4.10 summarises and concludes on this chapter.

4.2 Data

The dataset used in this study includes seasonally adjusted² macroeconomic data spanning 33 years of quarterly observations for the output gap, inflation, money supply, interest rate and the exchange rate over the period 1980:01 to 2012:04. Data was sourced from the IFS and the World Development Indicators (WDI) of the IMF and World Bank (WB) databases. The Gross domestic product (GDP) for Algeria, Ghana, Kenya³ and Nigeria were in annual form and the money supply for the sampled countries, obtained from the World Bank. The interest rate, the CPI, the exchange rate and index of world commodity food prices were all quarterly series obtained from the IFS.

Data for Nigeria begins from 1988:04 to 2012:04 when its monetary policy became active. The post 1986 period in Nigeria emphasises the role of money market based interest rates and the adoption of a floating exchange rate mechanism in 1987. This is in contrast to the pre 1986 period where monetary policy was passive, relying on selective mechanisms (such as credit controls and the minimum reserve requirements) due to the underdeveloped financial markets. In Tunisia the sample size starts from 1988:03 to 2012:04 due to the fact that its monetary policy became effective in 1987, where the intermediary objective used was monetary targeting. The other reason being that industrial production⁴ is used as a proxy for the GDP and partly due to the availability of data for the CPI before 1988. In Uganda, the data set runs from 1982:02 to 2012:04 to eliminate the exchange rate shocks that led to the depreciation of the Ugandan Shilling in 1981.

²This has been conducted following the Census X12 approach which is often used in the literature to consider the impact of seasonality on a time series.

³This is due to the non-availability of quarterly data in 2012 from the IMF.

⁴See Kalyvitis and Michaelides (2001), using similar framework.

We use standard interpolation techniques⁵ due to the non-availability of quarterly data for the GDP and the money supply to derive quarterly observations from the annual data series. This approach is closely related to that of Wymer (2012), Moosa (1995, 2013) and Suliman (1995) using a numeric quadratic method, in contrast to the traditional regression based techniques. The latter approach requires a regression of the regressand y_t on a set of regressors, $x_{i,t}$ for $i = 1, \dots, N$ (number of regressors) and $t = 1, \dots, T$ (number of observations) and then uses the estimated parameters to predict quarterly observations (Chow and Lin, 1971). Although the regression based approach is a straight forward technique, it is flawed for the following reasons: firstly, the arbitrary selection of regressors without economic theory to obtain forecasts of economic series, it may induce unreliable estimates of the predicted quarterly observations and secondly, it does not account for measurement errors for predicting quarterly from annual data series (Suliman, 1995). The numeric quadratic method does not suffer from any of these limitations and thus is a more plausible technique for interpolating data. The algebraic discussion of the data interpolation are reserved for the appendix to maintain consistency in the flow of the argument, but the description of the data is analysed hereafter.

4.2.1 Definitions of the Data

The output gap (y_t) is the detrended series of the log of real GDP, using the HP filter. This approach is the most widely used method in macroeconomics to decompose the cyclical component of a series (Bjornland, 2000; Orphanides and van Norden, 2002 and Ravn and Uhlig, 2002). The HP filter measures the business cycle, based on the assumption that the output gap is decomposed into; the trend component of output (g_t^{tr}) and the cyclical component (c_t^{hp}). This means that the output gap is the proportional difference between output and its trend level which can be expressed as:

$$y_t = g_t^{tr} + c_t^{hp} \iff c_t^{hp} = y_t - g_t^{tr} \quad (4.1)$$

From equation (4.1), the HP filter chooses g_t^{tr} to minimise the variance of the cyclical component of y_t subject to the smoothing parameter to give:

$$HP_{filter} \{g_t^{tr}\} = \arg \min \sum_{t=1}^T (y_t - g_t^{tr})^2 + \lambda \sum_{t=2}^T \{(g_{t+1}^{tr} - g_t^{tr})^2 - (g_t^{tr} - g_{t-1}^{tr})^2\} \quad (4.2)$$

⁵Such as the quadratic match sum approach, where the sum of the quarterly series is exactly approximated to the original data.

where, λ is the smoothing parameter and it is defined conventionally as 100 times the square of the frequency of the data (Ravn and Uhlig, 2002).⁶ The term:

$$\lambda \sum_{t=2}^T \left\{ (g_{t+1}^{tr} - g_t^{tr})^2 - (g_t^{tr} - g_{t-1}^{tr})^2 \right\}$$

penalises deviations in the growth rate of the trend component. Differences exist in the literature as to what value lambda takes with respect to the data series - annual (A), quarterly (Q) or monthly (M) data types. According to Backus and Kehoe (1992) and Mohr (2005),⁷ $\lambda_A = 100$; Baxter and King (1999): $\lambda_A = 10$, $\lambda_Q = 1600$; Ravn and Uhlig (2002): $\lambda_A = 6.25$, $\lambda_Q = 1600$ and $\lambda_M = 129600$; Orphanides and van Norden (2002): $\lambda_Q = 1600$. Although different values have been used for annual and monthly datasets, there is a general consensus in the literature that the recommended choice for quarterly data is $\lambda_Q = 1600$ (Hodrick and Prescott, 1997; Bjornland, 2000). This choice of the output detrending value has been applied to quarterly time-series data for the real GDP for each of the African economies.

Giordani (2004), Boivin and Giannoni (2006) document that the output gap provides the best measure of movements in the business cycle, rather than the output growth or the trend level of output. This is because the former approach assumes that all movements in output are due to the business cycle. The output growth measure ignores the process of economic growth that may change the level of economic activity and hence changes in the business cycle. The trend level of output assumes that output increases by a constant amount (κ) in each period. This is not realistic as output may decline during recessions and increase in a boom. The plausibility of the output gap rests on the fact that it does not suffer from any of these limitations and so the quarterly data has been used to capture movements in the business cycle.

Inflation (π_t) is measured as the annualized rate of change in the CPI between two subsequent quarters.⁸ That is, $\pi_t = [(p_t - p_{t-4})/p_{t-4}]$, where p_t is the CPI at current period, t , to denote the consumer price level. This is expressed in terms of percentages as:

$$\pi_t = \left[\frac{p_t - p_{t-4}}{p_{t-4}} \right] \times 100$$

⁶For annual data, $\lambda = 100 \times 1^2$, quarterly data, $\lambda = 100 \times 4^2$ and for monthly data, $\lambda = 100 \times 12^2$ respectively. The larger the value of λ , the smoother the series and the greater the variability of the output gap (Orphanides and van Norden, 2002).

⁷Mohr (2005) argues that this value of lambda for annual data has been used by the European Central Bank when approximating business cycles.

⁸See Zhang (2009) and Clarida et al (2000) for similar analogy of defining the inflation rate.

Constituents of the CPI includes baskets of all items (established from the sources of data).

Following the established literature, we derive year-on-year rates of change of index of world commodity food prices (pc_t), representing changes in the prices of sensitive commodities and changes in information sets according to the monetary policy (Bernanke and Mihov, 1998). Durevall et al (2013) documented that real commodity price shocks broadly explains asymmetric relationships in African economies and suggests the inclusion of commodity price inflation when modelling the dynamic impact of monetary policy shocks on the real economy.⁹

The broad money supply growth (m_t) is the year-on-year rate of change of money (m_1) plus quasi money (m_0), collectively referred to as broad money. This comprises the sum of currency outside the banks, time and demand deposits (excluding those of the central government), savings as well as foreign currency reserves. This is established from the sources of the data. The short-term nominal interest rate (i_t) represents monetary policy instrument and innovations in monetary policy reaction functions.

The exchange rate (er_t) is the nominal effective exchange rate, which is the national currency per units of foreign currencies which are the SDR. This thesis uses the nominal exchange rate and not the real exchange rate in order to determine the effectiveness of the monetary policy transmission mechanism. Changes in inflation makes it unsuitable for the central bank to target the real exchange rate as the nominal anchor for ensuring price stability and increasing output growth (Akinboade et al, 2004).

All data series are transformed to their growth rates, excluding non-trending series such as the interest rate. This approach follows the Clarida et al (2000) assumption that the interest rate is stationary because the presence of a unit root would imply a time-varying trend in monetary policy. As was mentioned in Chapter 3, the sampled of countries include; Algeria, Botswana, Ghana, Kenya, Nigeria, South Africa, Tunisia and Uganda. These are countries with a relatively large GDP and with a strong emphasis on monetary policy in order to reduce inflation to target levels. The next section provides a brief discussion of the sectoral components of these economies in order to determine whether they are

⁹Index of world commodity food prices depicts three situations; as an external shock to monetary policy, to mitigate the impact of the “price-puzzle” effect and the long-run neutrality condition between monetary policy and commodity prices (Giordani, 2004).

service or agriculturally driven economies and their relative contribution to GDP. This is followed by a brief descriptive analysis of the variables.

4.3 Sectoral Analysis of the African economies

This section further underpins the rationale for selecting the African economies used in the study by discussing the sectoral component analysis of the contribution of the service, mineral and agricultural sectors to the GDP. The aim is to emphasise the importance of GDP as a measure of overall economic activity and thus the relative importance of macroeconomic policies in the African economies, aimed at maintaining a positive real GDP growth rate.

The Algerian economy has experienced strong economic growth with an estimated GDP of U.S\$325.0 billion in 2012 with an annual consumer price inflation of 3.9%. The real GDP grew by 2.5% mainly attributed to its natural resources like hydrocarbons, while the oil and gas sectors contributed 70% of government revenue and more than 95% of total exports. The huge dependence on the oil sector makes Algeria susceptible to external shocks such as fluctuations in hydrocarbon prices. The contribution of agriculture to GDP is 8.4% while imports account for over 45% to meet domestic consumption (as only 3% of the total land area is arable). The main agricultural crops include; wheat, barley and potatoes. The industrial sector constitutes 61.1% of GDP, while the contribution of the service sector to GDP is 31.5%.

Botswana recorded the highest average economic growth rate in the World of approximately 9% annually between 1966 until 2006¹⁰ due to the sale of its diamonds and with a strong macroeconomic policy. The industrial (including mining) and services sectors contributed 52.6% and 45.8% to GDP, while the resulting 1.6% of GDP emanated from agriculture. The global economic meltdown of 2007-2008 led to a decline in Botswana's main export commodity (diamonds) as real GDP contracted by 5.2%.

Ghana is a service sector driven economy endowed with diverse mineral and natural resources which includes diamonds, oil, gold, bauxite and cocoa. The combination of rich resource hydrocarbons, industrial minerals and primary manufacturing has led to Ghana being one of the fastest growing economy in Africa since 2010 with a growth rate of 8.5% and a nominal GDP of U.S\$43 billion. The

¹⁰Inflation remained low during this period, excluding a series of external shocks (such as droughts) from 1992 to 1994.

service sector constitutes 50% of GDP, while the contribution of agriculture (with cocoa as the main export commodity) and the industrial sectors are 22.7% and 27.3% respectively.

Kenya is a market-based economy due to the liberalization of state-owned enterprises as part of the SAP from the IMF and World Bank. The agricultural sector contributes 24.2% of total GDP, which is estimated at U.S\$41.84 billion. The service sector constitutes about 61.0% of GDP as against 14.8% from the industrial sector. The main agricultural products include, rice, wheat, hides, skins and dairy products which accounted for 7% of real GDP growth rate in the mid 1960's.

Nigeria is a mixed economy, where the service sector contributes 30%, industrial sector (including oil, accounts for 29% and agricultural sector constitutes 40% of GDP which is estimated at U.S\$451 billion. In contrast to many African economies, Nigeria recorded a boom in the 1970's, which led to the economy relying to an unhealthy extent on crude oil production (which accounts for over 70% of government revenue) out a neglecting of the development of the agricultural sector.

The South African economy is the largest in Africa (second is Nigeria), with an estimated GDP of U.S\$585.6 billion in 2012. According to the IMF (2014) regional economic outlook, South Africa is a middle-income Sub-Saharan country as compared to other African economies which are often classified as low income states. The contributions of the service, industrial and agricultural sectors to GDP are 65.9%, 31.6% and 2.5% respectively. Despite rapid economic growth, the current unemployment rate is 25%, amid a slow and volatile global economy.

Tunisia is a globally competitive economy, which was ranked first in Africa in 2008/2009, due to its endowments of agricultural products, minerals (oil, phosphates), manufacturing and petroleum, with an estimated GDP of U.S\$95.6 billion. The economy is service driven accounting for 53.7% of GDP, while agriculture and the industrial sectors constitute 11% and 35.3% of the GDP respectively.

In contrast to most African economies, the economy of Uganda has suffered some severe shocks, ranging from the fall in commodity prices of its major export commodities, chronic economic policies and political instability. Annual GDP growth averaged 7.4% from 1994/95 until 1998/99. The agricultural sector constitutes 27% of GDP. The implementation of a wide range of macroeconomic

policies and structural reforms has enabled Uganda to achieve low inflation rates and reasonable economic growth following the discovery of gas and oil resources.

Tables 4.1 to 4.6 report descriptive statistics for the variables, which are the mean, median and SD as well as the minimum and maximum values in the current sample (T).

Table 4.1: Summary Statistics for the Output Gap

Country	Mean	Median	SD	Min	Max
Algeria	-0.001	0.003	0.035	-0.082	0.090
Botswana	0.000	0.004	0.030	-0.074	0.067
Ghana	-0.002	0.012	0.101	-0.381	0.193
Kenya	0.000	0.012	0.059	-0.231	0.114
Nigeria	0.003	0.020	0.088	-0.220	0.231
South Africa	0.001	0.000	0.016	-0.039	0.044
Tunisia	-0.007	-0.128	1.370	-2.584	4.949
Uganda	0.002	0.002	0.073	-0.342	0.193

Note: Min & Max = minimum and maximum values
Results are obtained using the Eviews software.

Table 4.2: Summary Statistics for Inflation

Country	Mean	Median	SD	Min	Max
Algeria	9.86	6.07	8.72	0.04	33.08
Botswana	9.89	9.22	2.85	5.63	17.90
Ghana	29.84	20.34	28.87	3.18	143.97
Kenya	13.06	11.31	9.87	-1.80	56.36
Nigeria	21.80	13.09	19.97	-1.88	87.89
South Africa	9.74	9.42	4.67	0.43	19.25
Tunisia	4.34	4.02	1.81	1.19	8.85
Uganda	36.18	9.96	59.54	-4.32	275.62

Note: Min & Max = minimum and maximum values.

Table 4.3: Summary Statistics for Money Supply

Country	Mean	Median	SD	Min	Max
Algeria	3.98	3.89	2.14	0.13	12.36
Botswana	4.91	3.72	5.03	-4.47	19.37
Ghana	9.55	9.74	3.09	2.55	14.82
Kenya	3.89	3.76	2.22	-0.00	10.12
Nigeria	7.28	5.80	4.13	1.83	16.62
South Africa	3.66	3.69	1.58	0.17	6.87
Tunisia	2.64	2.75	0.99	0.97	4.99
Uganda	11.44	5.90	11.23	1.35	44.54

Note: Min & Max = minimum and maximum values.

Table 4.4: Summary Statistics for the Interest Rate

Country	Mean	Median	SD	Min	Max
Algeria	6.46	4.75	3.89	2.75	21.00
Botswana	11.53	12.25	2.91	5.75	15.50
Ghana	23.53	20.50	9.90	10.50	45.00
Kenya	3.44	3.25	2.38	0.56	14.56
Nigeria	14.22	13.50	4.32	6.00	26.00
South Africa	12.23	12.00	4.31	4.78	21.85
Tunisia	1.74	1.50	0.63	0.92	2.98
Uganda	22.33	16.17	13.06	5.99	55.00

Note: Min & Max = minimum and maximum values.

Table 4.5: Summary Statistics for the Exchange Rate

Country	Mean	Median	SD	Min	Max
Algeria	3.55	4.36	1.28	1.60	4.80
Botswana	5.33	4.88	3.38	0.94	11.94
Ghana	0.69	0.24	0.83	0.00	2.91
Kenya	3.97	4.42	0.86	2.27	5.04
Nigeria	4.32	4.93	1.12	1.97	5.50
South Africa	6.69	6.19	4.13	0.95	15.23
Tunisia	1.74	1.50	0.63	0.92	2.98
Uganda	6.41	7.42	2.36	0.05	8.39

Note: Min & Max = minimum and maximum values.

Table 4.6: Summary Statistics for Commodity Price Index

Mean	1.958
Median	1.110
Standard Deviation	11.910
Min	-23.394
Max	45.747

Note: See Table 4.1. Commodity price index

4.4 Methodology: Testing for a Unit Root

The data is examined by conducting a battery of unit root tests such as the ADF and PP tests as well as the KPSS test for stationarity which is considered robust to the unit root tests. As a major contribution to the chapter, the LS test is incorporated to endogenously determine structural breaks from the data. This is not otherwise captured by the other unit root tests which are the ADF, PP and the KPSS.

4.4.1 The Augmented Dickey-Fuller (1979,1981) Test

The ADF test, is a test for a unit root for a variable (y_t) against the alternative hypothesis (H_1) of stationarity. Consider an autoregressive model of the form given in equation (4.3), with a constant term (δ_0) and deterministic time trend (δt) as:

$$y_t = \delta_0 + \delta t + \alpha y_{t-1} + \varepsilon_t \quad (4.3)$$

where, $\varepsilon_t \sim i.i.d(0, \sigma^2)$ is a white noise error term, which is not correlated. Subtracting y_{t-1} from both sides of equation (4.3) and by accounting for autocorrelation, gives the ADF test regression of the form:

$$\Delta y_t = \delta_0 + \delta t + \rho y_{t-1} + \sum_{j=1}^m \rho_j \Delta y_{t-j} + \varepsilon_t$$

where, $\rho = \alpha - 1$, m is the number of lags is determined by the Schwarz information criterion (SIC) with 8 lags, such that ε_t is serially uncorrelated and Δ is the difference operator, implying that $\Delta y_t = y_t - y_{t-1}$. The augmentation term Δy_{t-j} is used to approximately define the autoregressive moving average (ARMA) structure of ε_t (Said and Dickey, 1984). The unit root is insignificant if $|\rho| < 1$, which means the series under consideration is stationary. Critical values are taken from Mackinnon's (1996) one-sided distribution at the 5% level.

4.4.2 The Phillips-Perron (1988) Test

The PP test has been developed as an alternative non-parametric method for testing unit roots. The ADF test uses a parametric autoregression to approximate the ARMA structure of the error in the test regression. The two tests differ in their treatment of serial correlation and heteroskedasticity in the errors. The PP test regression is given as:

$$\Delta y_t = \delta_0 + \delta t + \rho y_{t-1} + \varepsilon_t \quad (4.4)$$

where ε_t is serially correlated, but whitened by the Newey-West (1987) heteroskedasticity-autocorrelation consistent (HAC) correction factor, so that serial correlation does not affect the asymptotic distribution of the modified test statistics; Z_ρ and Z_t , under levels and in first difference, as denoted below.

$$Z_\rho = T_{\hat{\rho}} - \frac{1}{2} \frac{T^2(Se(\hat{\rho}))}{\hat{\sigma}^2} (\hat{\lambda}^2 - \hat{\sigma}^2) \quad (4.5)$$

$$Z_t = \left(\frac{\hat{\sigma}^2}{\hat{\lambda}^2} \right)^{\frac{1}{2}} t_{\rho=0} - \frac{1}{2} \left(\frac{\hat{\lambda}^2 - \hat{\sigma}^2}{\hat{\lambda}^2} \right) \left(\frac{T(Se(\hat{\rho}))}{\hat{\sigma}^2} \right) \quad (4.6)$$

Where $T_{\hat{\rho}}$ is the estimate of the test regression, $t_{\rho=0}$ is the t-ratio of $T_{\hat{\rho}}$ under the null hypothesis that $\rho = 0$ and $Se(\hat{\rho})$ is the coefficient standard error. $\hat{\lambda}^2$ and $\hat{\sigma}^2$ are consistent estimates of the variance parameters, defined as:

$$\sigma^2 = \lim_{T \rightarrow \infty} T^{-1} \sum_{t=1}^T E(\varepsilon_t^2)$$

$$\lambda^2 = \lim_{T \rightarrow \infty} \sum_{t=1}^T E \left(T^{-1} \sum_{t=1}^T \varepsilon_t^2 \right)$$

The robustness of the PP test stems from the fact that the variance of the least squares residuals ($\hat{\varepsilon}_t$) is a consistent estimate of σ^2 and the Newey-West (1987) long-run variance estimate (λ^2), using $\hat{\varepsilon}_t$ without any lag specification (truncation), unlike the ADF test. The unit root is insignificant if $|\rho| < 1$.

4.4.3 Kwiatkowski, Phillips, Schmidt and Shin (1992) Stationarity Test

In contrast to the ADF and PP tests for a unit root, the KPSS test assumes that y_t is stationary ($y_t \sim I(0)$) as against the alternative hypothesis of non-stationarity ($y_t \sim I(1)$). We have employed the KPSS test in order to compare with the ADF and PP procedures, to determine if the same conclusion is obtained. The test regression is given as:

$$y_t = \delta_0 + \delta t + \mu_t + \varepsilon_t \quad (4.7)$$

where, $\mu_t = \mu_{t-1} + \epsilon_t$, $\epsilon_t \sim RW(0, \sigma_\phi^2)$ is a pure random walk, with innovations, σ_ϕ^2 , and examined under the following hypotheses. $H_0 : \sigma_\phi^2 = 0 \rightarrow y_t \sim I(0)$ against $H_1 : \sigma_\phi^2 > 0 \rightarrow y_t \sim I(1)$. Inference about stationarity is based on the score statistics, which is the LM test and its computed below as:

$$KPSS_{LM} = \left(\frac{T^{-2} \sum_{t=1}^T \hat{s}_t^2}{\hat{\lambda}^2} \right)$$

where, $\hat{s}_t^2 = \sum_{j=1}^t \hat{\epsilon}_j$ is a cumulative residual function and $\hat{\epsilon}_j$, the residuals from the estimating equation (4.7).

4.4.4 Testing Hypotheses Under Trend Stationarity

To briefly summarise the variants of unit root tests, we consider two formulations for testing hypotheses under trend stationarity; with a deterministic trend and a constant and with a constant only. In computing unit root tests for inflation, index of world commodity food prices, the broad money supply and the output gap (trending time-series), the following test regression was used in order to account for the correct deterministic trend.

$$y_t = \delta_0 + \delta t + \rho y_{t-1} + \varepsilon_t \quad (4.8)$$

A constant and a trend is included to capture the deterministic trend under the alternative hypothesis. We tested the following hypotheses; $H_0 : \rho = 1 \Rightarrow y_t \sim I(1)$ under the null with a trend (δt) against $H_1 : |\rho| < 1 \Rightarrow y_t \sim I(0)$ with a constant and a trend ($\delta_0 + \delta t$).

For the non-trending series such as interest rate and the exchange rate, the test regression follows:

$$y_t = \delta_0 + \rho y_{t-1} + \varepsilon_t \quad (4.9)$$

It is examined using the following hypotheses; under the null $H_0 : \rho = 1 \Rightarrow y_t \sim I(1)$ without a drift (constant only which is δ_0) versus $H_1 : |\rho| < 1 \Rightarrow y_t \sim I(0)$ with a non-zero mean.

4.5 Endogenous Structural Break Tests

This section focuses on the LS test, which is considered to be plausible compared to that of Perron's (1989) structural break test in levels and trend. The latter test applies a known exogenous structural break in the ADF test. This method is criticized for the fact that it derives critical values, based on the assumption of no breaks under the null hypothesis (Nunes et al, 1997). As a result Zivot

and Andrews (1992) (ZA) proposed the endogenous determination of structural breaks from the data.¹¹ Although the ZA test is an alternative to an exogenous break point tests, it is flawed because it select break points exhibiting a large bias and size distortions (Lee and Strazicich, 2001). Against this background, we consider the LS two breaks structural unit root test which is not affected by spurious rejections under both the null and the alternative hypotheses.

4.5.1 Testing Methodology

This empirical procedure assumes the following data generating process (DGP) for the series y_t representing the variables:

$$y_t = \delta' z_t + \varepsilon_t \quad (4.10)$$

where $\varepsilon_t = \phi\varepsilon_{t-1} + \mu_t$, $\mu_t \sim i.i.d(0, \sigma^2)$ is a contemporaneous error term having a mean zero and a homoskedastic variance and z_t the vector of exogenous variables. Without accounting for a break in the series, $z_t = [1, t]'$ corresponding to the model developed by Schmidt and Phillips (1992) which does not consider structural breaks in the data. In order to consider the effects of a single structural break in intercept and in trend, we have followed the Lee and Strazicich (1999) and Lee et al (2004) approaches. This method considers a one-time (t) shift in intercept and change in trend¹² under the alternative hypothesis that $z_t = [1, t, D_{1t}, D_{2t}]'$ where the response function is defined by:

$$DT_t = \begin{cases} t - TB, & t \geq TB + 1 \\ 0 & otherwise \end{cases} \quad (4.11)$$

where TB indicates the time-period of the structural breaks at which they occurred. D_{1t} and D_{2t} are the dummy variables which is defined in equation (4.11) as $D_j t = 1$ for $t \geq TB + 1$, $j = 1, 2$ and 0 otherwise. The break function is defined by $\lambda = TB/T$, where T represents the total number of observations used in endogenously determining the breaks.

Since most macroeconomic variables change over time, we have employed the LS method which is used to account for the simultaneous changes in level and in trend of the variable y_t . This method considers two structural breaks. This has been referred to as “Model C” in the literature for a shift in the intercept and change in trend under the following alternative hypothesis. $z_t =$

¹¹Lumsdaine and Papell (1997) extended the ZA (1992) test to allow for two breaks in trend and level, which suffers from spurious rejections (under the null hypothesis) as opposed to the LS test.

¹²This has been referred to as “Model A” in the literature. See Perron (1989).

$[1, t, D_{1t}, D_{2t}, DT_{1t}^*, DT_{2t}^*]'$ where,

$$DT_{jt} = \begin{cases} t - TB_j, & t \geq TB_j + 1 \\ 0 & otherwise \end{cases}, j = 1, 2$$

The unit root null hypothesis with structural breaks means that $H_0 : \phi = 1$ and the alternative hypothesis implies that $H_1 : \phi < 1$. The location of the break $\lambda_j = TB_j/T$ is determined by the data. The parameter TB_j indicates the time periods for the breaks.

4.5.2 The LM Test Statistic

The LS minimum test allows for breaks in levels and trend of the variables, which is derived from Perron's (1989) LM test. According to Perron's (1989) score principle, the two-break minimum unit root statistic is obtained from the following regression:

$$\Delta y_t = \delta' \Delta z_t + \rho \bar{\Gamma}_{t-1} + \sum_{j=1}^{\ell} \psi_j \Delta \bar{\Gamma}_{t-j} + \varepsilon_t \quad (4.12)$$

where, Δ is the difference operator, while the detrended series of the DGP ($\bar{\Gamma}_t$) is given as; $\bar{\Gamma}_t = y_t - \tilde{\eta}_x - z_t \tilde{\sigma}$ for $t = 2, 3 \dots T$. $\tilde{\sigma}$ is a vector of coefficients in the regression of Δy_t on Δz_t . Denoting the first observations of y_t and z_t as y_1 and z_1 respectively such that $\tilde{\eta}_x$ is given by $y_1 - z_1 \tilde{\sigma}$. The expression $\Delta \bar{\Gamma}_{t-j}$, for $j = 1, 2 \dots \ell$ terms are included to account for serial correlation in ε_t .

The critical values under a trend and a constant with two endogenous breaks depends on the location of the breaks (λ_j). In the testing procedure we have allowed for a maximum lag of 8 (which is plausible with quarterly data) in order to account for serial correlation in the auxiliary regression to determine the breaks. The deductive approach (general-to-specific method) is used to determine ℓ at each possible combination of break points, $\lambda = (\lambda_1, \lambda_2)$. The testing procedure requires the maximum number of lagged differenced terms, $\ell = 8$ until the last term to examine if it is significantly different from zero and tested at the 10% level.¹³ This means the 10% significance level is used to determine the optimal lag structure in the model. If this test is insignificant we use, $\ell = 7$ and so on until, $\ell = 0$.

Under the null hypothesis, a unit root with a structural break is significant if $\rho = 0$ as against the alternative hypothesis of stationarity with structural breaks. That is we can determine the unit root null hypothesis for determining the test

¹³This follows a critical value of 1.645 for an asymptotic normal distribution (LS).

statistic $\tau(\tau)$. The minimum LM statistic for a given τ is based on a grid search for the number of breaks. The LM statistic is derived by using a 10% trimming off both sides of the samples. This is equivalent to samples in the interval $[(0.1T, 0.9T)]$ and is used to eliminate end points as break dates from the number of observations T .

$$LM_{\tau} = \inf_{\lambda} \tilde{\tau}(\lambda)$$

The unit root tests with two structural breaks are determined where the test statistic is minimized, together with the optimal lag length for the break dates.

Compared to the ADF and PP tests that select the augmented number of lagged terms, LS found that their deductive approach performs well for any sample size. The main advantage of the two-breaks minimum LM unit root test over other tests is that it determines the break points and unit roots endogenously from the data and does not suffer from spurious rejections in the presence of a unit root with structural breaks.

4.6 Results of Unit Root Tests

The ADF, PP and the KPSS tests are reported in Table 4.7 through to 4.9. The ADF test statistics for the variables are reported in Table 4.7. Column 1 shows that the output gap is stationary in levels at the 5% level for all the sampled countries. Inflation is stationary in levels in Kenya, Nigeria and Uganda, while it is stationary in first differences for the other African economies. In Algeria, Ghana, Nigeria, Tunisia and Uganda the broad money supply is stationary in levels, with no evidence against a unit root for Botswana, Kenya and South Africa. There is also evidence to suggest that the interest rate is difference stationary using the ADF test with the exception of South Africa, where interest rate appear to be stationary in levels. The exchange rate is stationary in levels for Ghana, South Africa and Tunisia, while there is no further evidence against a unit root for all the other countries. It appears that commodity price is stationary in levels using the ADF, PP and the KPSS tests.

The results for the PP test are reported in Table 4.8. Similar conclusions using the ADF test are derived for the output gap, which is stationary in levels for all countries. Inflation is stationary in Ghana and Kenya, while it is only stationary in first difference for all the other countries. The money supply is stationary for Algeria, Botswana, Ghana and Tunisia, while there is no further evidence

against a unit root for all the other countries. For all countries, it appears that the interest rate is stationary in first differences. Similar results are obtained for the exchange rate, except for Ghana. A cross examination of these unit root test results reveals that the money supply is the most stationary variable according to the ADF and PP tests.

The results for the KPSS test are shown in Table 4.9. The results show that the output gap is stationary for the countries studied. Although inflation appears to be non-stationary using the ADF and PP tests the null hypothesis of stationarity is not rejected using the KPSS test, with the exception of Tunisia. The KPSS test also suggests that the growth rate of the broad money supply is stationary for all countries. There is no further evidence against the presence of a unit root for the interest rate in Tunisia, while the interest rate is stationary in Botswana, Nigeria and South Africa at the 1% level. There is mixed findings for the exchange rate, which is stationary in Nigeria, South Africa and Tunisia but not further evidence against the presence of a unit root for all the other countries. It appears the the exchange rate in Uganda is stationary, after differencing twice. Compared to the ADF unit root test results more weight is put on the KPSS test for the null of stationarity.

Table 4.7: Augmented Dickey-Fuller (1979,1981) Unit Root Test

Table 4.7: ADF Unit Root Test

Country	y_t	π_t	$\Delta\pi_t$	m_t	Δm_t	i_t	Δi_t	er_t	Δer_t	pc_t
Algeria	-4.44**	-2.24	-3.19**	-3.38*	-	-1.16	-15.44**	-0.37	-7.76**	-7.06**
Botswana	-5.54**	-2.02	-7.99**	-2.17	-3.83**	-2.43	-5.77**	-2.63	-10.97**	
Ghana	-4.72**	-2.11	-6.14**	-3.98**	-	-1.50	-7.61**	-3.08**	-	
Kenya	-4.42**	-3.64**	-	-2.65	-4.45**	-2.05	-3.65**	-1.81	-8.12**	
Nigeria	-5.44**	-3.38*	-	-3.69**	-	-2.20	-8.86**	-1.99	-9.84**	
South Africa	-4.78**	-2.91	-5.85**	-2.98	-3.68**	-2.69*	-	-3.73**	-	
Tunisia	-4.85**	-1.17	-10.30**	-3.24*	-	-1.86	-3.11**	-3.26*	-	
Uganda	-5.40**	-3.33*	-	-4.56**	-	-1.74	-10.34**	-2.02	-10.62**	

Note: * *, * and * indicates rejection of the null hypothesis of unit root at the 1%, 5% and 10% levels.

– means the variable is stationary in levels, we do not consider taking the first difference.

Results are obtained using the Eviews software.

Table 4.8: Phillips-Perron (1988) Unit Root Test

Table 4.8 PP Unit Root Test

Country	y_t	π_t	$\Delta\pi_t$	m_t	Δm_t	i_t	Δi_t	er_t	Δer_t	pc_t
Algeria	-2.89*	-1.94	-5.49**	-3.37*	-	-1.30	-15.44**	-0.53	-8.14**	-3.40**
Botswana	-3.46**	-3.11	-11.76**	-3.77**	-	-2.19	-10.25**	-2.75	-10.96**	
Ghana	-4.22**	-3.40*	-	-4.47**	-	-1.51	-8.06**	-3.83**	-	
Kenya	-3.52**	-3.32*	-	-2.44	-9.44**	-2.46	-6.56**	-1.92	-8.02**	
Nigeria	-4.05**	-2.59	-6.02**	-2.58	-4.81**	-2.20	-8.78**	-2.04	-9.84**	
South Africa	-3.54**	-2.88	-10.49**	-3.11	-5.23**	-2.31	-7.33**	-3.25	-10.65**	
Tunisia	-4.66**	-2.70	-6.07**	-3.17*	-	-2.34	-4.82**	-2.70	-7.95**	
Uganda	-7.37**	-2.54	-11.11**	-2.45	-8.07**	-1.79	-10.39**	-2.02	-10.64**	

Note: *, **, and * indicates rejection of the null hypothesis of unit root at the 1%, 5% and 10% levels.

— means the variable is stationary in levels, we do not consider taking the first difference.

Table 4.9: Kwiatkowski et al (1992) Stationarity Test

Table 4.9 KPSS Stationarity Test

Country	y_t	π_t	$\Delta\pi_t$	m_t	i_t	Δi_t	er_t	Δer_t	pc_t
Algeria	0.053	0.157	-	0.074	0.291	-	0.287 ⁺	0.327	0.09
Botswana	0.029	0.075	-	0.082	0.671 ^{***}	-	0.22 ⁺	0.162	
Ghana	0.030	0.099	-	0.046	0.312	-	1.246 ⁺	0.053	
Kenya	0.037	0.082	-	0.135	0.336	-	1.29 ⁺	0.360	
Nigeria	0.035	0.083	-	0.050	0.682 ^{***}	-	0.213	-	
South Africa	0.046	0.133	-	0.065	0.622 ^{***}	-	0.101	-	
Tunisia	0.023	0.336 ⁺	0.091	0.059	0.172 ⁺	0.111	0.068	-	
Uganda	0.039	0.122	-	0.128	0.461	-	0.288 ⁺	0.099	

- means the variable is stationary in levels, we do not consider taking the first difference.

+ denotes rejection of the null hypothesis of stationarity at the 5% level.

* * * indicates stationarity at the 1% level.

4.7 Endogenous Structural Break Tests Results

A major contribution in this chapter is to allow for structural breaks in the unit root tests. This was accomplished by using the LS test. These results are reported in panel A and B of Tables 4.11 to 4.14 for the African economies, while Table 4.10 contains the LS test critical values at various levels of significance.

In Algeria, inflation, the output gap and money supply were all stationary in levels, with the exception of the interest rate and the exchange rate. In Botswana, the output gap is stationary in levels, while there is no further evidence against the null hypothesis of a unit root for all the other variables. In Ghana and Uganda, the series were all stationary in levels. Also, in Kenya and South Africa, the LM test suggests that all series are stationary in levels, except for the money supply in Kenya and the money supply and the interest rate for South Africa. In Nigeria, there is no additional evidence against the null hypothesis of a unit root for the money supply and the interest rate, while the exchange rate is stationary in levels in addition to the output gap and inflation. In Tunisia, the series are stationary in levels, except for the money supply. This is potentially due to instability in the money demand function during the economic reforms in the mid 1990's to early 2000's. Although mixed results are obtained for the money supply, interest rate and the exchange rate, on the contrary, inflation and the output gap are stationary for all countries, except for Botswana where inflation is $I(1)$.

4.8 Timing of Structural Breaks

Structural break dates in levels and trend of the variables are identified for each country, which have occurred in the mid-eighties and nineties, caused by various external factors, institutional frameworks and changes in macroeconomic reforms. These results are reported in Tables 4.16 to 4.23. Most of the significant events can be characterized based on the pre and post liberalization periods as well as the financial crisis. These timescales of events may explain the structural breaks of the variables for all the countries, as discussed in the background chapter earlier.

4.8.1 Pre-Liberalization Period: 1970's - 1986

This period emerged following the aftermath of the oil price shock in the late 1970's. The 1980's witnessed a fall in the prices of major export commodities which in turn led to negative GDP growth, accompanied by the Stock market crash between 1985 - 1986. SAP and stabilization programmes were initiated by the IMF and World Bank (from 1983 until late 1980's) in an attempt to overhaul

the structure of the economies by improving their macroeconomic policies. There was also a debt crisis during the 1980's which resulted from large borrowing and the consequences were insolvency in debts repayment. These fiscal deficits had a deteriorating impact on economic growth for the African economies which can be theorised under the liquidity constraint hypothesis (Fosu, 1999). This hypothesis suggests that debt servicing reduces the availability of funds for investment and because these debts were financed through short-term loans from the IMF, were based on some conditionality clauses such as the liberalization of state-owned companies aimed at enabling faster loan repayment, without considering the long-term implications for economic growth.

4.8.2 Post-Liberalization Period: 1986 - 1999

This period was characterized by large scale macroeconomic reforms accompanied by SAP's institutional frameworks. The main policy measures were deregulation of the financial sector to encourage a market-based economy, privatization of state-owned enterprises and the elimination of sectoral interest rates. This was evident in Nigeria, where in 1986 monetary policy included money-market interest rate based instruments and eliminated credit controls. Currency devaluation and salary reduction between 1992 to 1993 were among the policy measures enacted within the Great Moderation (1994 - 1995) periods. The IMF and the World Bank introduced the HIPC initiatives in 1996 and enhanced concessionary lending in 1999 to reduce the debt crises and to increase domestic management. Among a host of policies was the elimination of exchange rate controls (1998 - 1999) aimed at improving international competitiveness.

4.8.3 Economic Booms and Recession: 2000 - 2012

Large scale trade liberalization in the early 2000's led to Economic booms for many of the African economies. This was accompanied by exchange rate management and changes in macroeconomic reforms, including the introduction of the inflation targeting framework. The Global financial crisis (2007 - 2008) in turn contributed to negative output growth for most economies.

4.8.4 Analysis of the Timing of Structural Breaks

The timing of the two-breaks for the money supply and the interest rate in Algeria supports evidence of changes during the economic reform periods. Breaks for inflation and the money supply correspond to elections in 1992 and election of President Abdelaziz Bouteflika in 1999. The output gap break is consistent

with the Civil War (that began in 1991) accompanied by currency devaluations in 1994. In addition, the timing of the two-breaks minimum LM unit root test for commodity prices suggests external shocks during the period of the financial crisis of 2007 caused a break.

In Botswana, the output gap, money supply and interest rate signal evidence of structural breaks during the economic boom of (1980 to 2006) as a result of the demand for its diamonds. The inflation breaks coincided with exchange rate depreciations of the Botswana Pula by 5% in 1984 as a result of sanctions from the Apartheid in South Africa which is Botswana's main trading partner. The economic reforms from 1980 to 2006 correspond to structural breaks in the interest rate which was caused by the changes in macroeconomic policies. The exchange rate shows evidence of structural breaks during the exchange rate management period of (2005 to 2011), following the currency devaluation in 2003 and the financial crises of 2007.

The LM two structural breaks test in Ghana for the output gap, inflation and the money supply coincide with the economic reforms and the IMF's stabilization programmes which were the introduction of SAP's under the initiative of the ERP. The break in inflation corresponds with the increase in the money supply and election in 1996 which led to the down fall of President Jerry Rawlings. The interest rate shows evidence of a structural break during the introduction of the HIPC frameworks with the completion date in 2004 based upon the achievement of broad macroeconomic objectives including good governance. Economic recession (1995 to 1999) and the currency devaluation captures the breaks in the exchange rate.

The timing of the structural breaks in Kenya for the variables is characterized by economic recessions and large scale trade liberalization policies enacted in the early 1990's to eliminate tariff barriers. The Kenyan economy stagnated between 1991 to 1993 as a result of negative supply shocks such as the drought. The inflation break corresponds to the election in 1992 - 1993. With regards to the money supply, structural breaks coincide with recession and suspension of the IMF concessionary loan by approximately U.S\$90 billion between 1997 - 1998 due to some conditionality clauses not being met regarding improving macroeconomic structures in the mid 1990's.

In Nigeria, the break tests revealed that the output gap, inflation, the money supply, the interest rate and the exchange rate indicated structural breaks dur-

ing the post liberalization periods characterized by large scale macroeconomic reforms and institutional frameworks. The money supply show evidence of a change in monetary policy framework from monetary targeting (that ended in 2006) to the introduction of interest rate targeting framework in 2007.

Regarding the timing of the structural breaks in South Africa, the output gap, inflation and money supply, coincide with economic reforms between (2000 to 2006). The inflation rate shows evidence of structural breaks during the financial crisis of 2007. There is evidence that the conduct of the election in 1990 affected the growth rate of the money supply and in subsequent periods up to 1992. Economic sanctions levied against the Apartheid regime affected the interest rate and the democratic election in 1994. This is attributed to a fall in the demand for money and investment, which resulted from the instability of the economy during this period, causing frequent changes in the interest rate. The currency devaluation (1995 to 2005) corresponds to structural breaks in the exchange rate.

The LM two structural breaks test in Tunisia suggests that the timing of the break for the output gap occurred during the recession of 2000 to 2004, characterized by negative output growth and a debt crises. Inflation and the money supply show evidence of a structural break during the economic reform period of (2000 to 2006) and SAP's institutional frameworks. The interest rate and the exchange rate suggests evidence of a structural break only during the post-liberalization period and the financial crises.

The timing of the breaks for the LM two structural breaks test in Uganda shows that the breaks in the output gap, inflation, the money supply, the interest rate and the exchange rate occurred during the economic reform period of 1986 to 2000. This includes the introduction of the HIPC framework in 1997 as a result of the debt crises between 1987 to the early 1990's. The second break in inflation is consistent with the period of monetary targeting framework.

4.9 Sensitivity Analysis

Following Lee and Strazicich (1999), the robustness of the estimation method was examined against the one break point minimum LM unit root test. This is to check whether the one break or the two breaks test is more appropriate to test for a unit root with a structural break and the dynamic composition of the African economies. This approach follows closely Lee et al (2004) who tested for

evidence of structural breaks in incomes for the OECD countries. The results obtained reveal that the break dates are qualitatively unchanged from those of the two structural breaks test. However, the one break point minimum LM test appears to exhibit lower power than the two breaks test. This is because the one break point test often fails to refute the null hypothesis of a unit root for the variables which may indicate that there exists more than one structural breaks and therefore these results have not been reported. Based on this finding, the two breaks minimum LM unit root test was chosen in favour of the one break point minimum LM test for a unit root with a structural break.

Table 4.10: Minimum LM Unit Root Critical Values

Location of breaks	Significant Levels (for Model C)		
Break Points $\lambda = \left(\frac{TB_1}{T}, \frac{TB_2}{T}\right)$	1% (*)	5% (**)	10% (*)
$\lambda = (0.20, 0.40)$	-6.16	-5.59	-5.27
$\lambda = (0.20, 0.60)$	-6.41	-5.74	-5.32
$\lambda = (0.20, 0.80)$	-6.33	-5.71	-5.33
$\lambda = (0.40, 0.60)$	-6.45	-5.67	-5.31
$\lambda = (0.40, 0.80)$	-6.42	-5.65	-5.32
$\lambda = (0.60, 0.80)$	-6.32	-5.73	-5.32

Note: Critical values depends on the location of the breaks.
These are obtained from Table 2 of LS (2003).

Table 4.11: Minimum LM Unit Root Test for Algeria and Botswana

Table 4.11a: Algeria Two-Breaks Minimum LM Unit Root Test for the period 1980:01 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	5	1993:02, 1997:03	-5.975**	$\lambda = (0.40, 0.60)$	Δy_t	7	1989:04, 1995:04	-6.574***	$\lambda = (0.30, 0.46)$
π_t	8	1990:02, 1996:04	-6.081**	$\lambda = (0.27, 0.49)$	$\Delta \pi_t$	8	1991:04, 1998:02	-6.924***	$\lambda = (0.30, 0.53)$
m_t	6	1986:04, 1999:04	-5.805**	$\lambda = (0.17, 0.60)$	Δm_t	7	1999:04, 2008:04	-8.329***	$\lambda = (0.58, 0.88)$
i_t	2	1989:04, 1997:04	-4.012	$\lambda = (0.30, 0.55)$	Δi_t	0	1994:01, 1995:02	-19.428***	$\lambda = (0.44, 0.48)$
er_t	3	1987:01, 1995:01	-5.302	$\lambda = (0.20, 0.46)$	Δer_t	0	1990:02, 1991:04	-10.643***	$\lambda = (0.32, 0.40)$
pc_t	8	1996:01, 2000:03	-4.342	$\lambda = (0.46, 0.60)$	Δpc_t	7	2007:02, 2008:01	-10.931***	$\lambda = (0.83, 0.85)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates. Results are obtained using the RATS software.

Table 4.11b: Botswana Two-Breaks Minimum LM Unit Root Test for the period 1980:01 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	8	1987:04, 1992:04	-5.989**	$\lambda = (0.20, 0.36)$	Δy_t	8	2007:03, 2008:04	-8.202***	$\lambda = (0.83, 0.87)$
π_t	8	1984:04, 1994:03	-3.343	$\lambda = (0.20, 0.42)$	$\Delta \pi_t$	7	1992:04, 1997:01	-9.597***	$\lambda = (0.36, 0.50)$
m_t	6	1987:04, 1997:04	-5.052	$\lambda = (0.20, 0.53)$	Δm_t	7	1984:01, 1985:01	-8.250***	$\lambda = (0.16, 0.20)$
i_t	2	1990:03, 2009:03	-3.807	$\lambda = (0.32, 0.90)$	Δi_t	0	1987:03, 1990:03	-9.938***	$\lambda = (0.23, 0.33)$
er_t	7	1997:04, 2003:01	-4.501	$\lambda = (0.52, 0.69)$	Δer_t	0	2007:03, 2009:01	-11.006***	$\lambda = (0.84, 0.90)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.12: Minimum LM Unit Root Test for Ghana and Kenya

Table 4.12a: Ghana Two-Breaks Minimum LM Unit Root Test for the period 1980:01 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	8	1984:04, 1989:03	-6.747***	$\lambda = (0.20, 0.25)$	Δy_t	7	1984:04, 1989:02	-6.770***	$\lambda = (0.20, 0.25)$
π_t	7	1984:02, 1996:03	-7.388***	$\lambda = (0.20, 0.48)$	$\Delta \pi_t$	3	1985:01, 1996:04	-13.382***	$\lambda = (0.20, 0.50)$
m_t	6	1989:01, 1990:04	-5.639**	$\lambda = (0.25, 0.31)$	Δm_t	7	1989:04, 1994:04	-6.869***	$\lambda = (0.26, 0.42)$
i_t	2	1995:02, 2005:03	-6.538***	$\lambda = (0.47, 0.78)$	Δi_t	3	1995:02, 1999:04	-9.329***	$\lambda = (0.46, 0.60)$
er_t	6	1999:02, 2005:02	-5.809**	$\lambda = (0.60, 0.77)$	Δer_t	1	2003:03, 2006:02	-8.255***	$\lambda = (0.72, 0.80)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.12b: Kenya Two-Breaks Minimum LM Unit Root Test for the period 1980:01 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	4	1991:04, 1995:04	-6.320**	$\lambda = (0.35, 0.45)$	Δy_t	8	1992:03, 1994:04	-7.281***	$\lambda = (0.35, 0.42)$
π_t	5	1991:04, 1994:04	-6.343**	$\lambda = (0.34, 0.44)$	$\Delta \pi_t$	7	1992:03, 1995:01	-8.810***	$\lambda = (0.35, 0.43)$
m_t	8	1991:02, 1998:03	-4.748	$\lambda = (0.30, 0.54)$	Δm_t	7	1984:04, 1993:02	-7.635***	$\lambda = (0.20, 0.46)$
i_t	8	1992:02, 1994:01	-5.376**	$\lambda = (0.34, 0.40)$	Δi_t	3	1992:04, 1995:04	-9.485***	$\lambda = (0.34, 0.47)$
er_t	3	1992:03, 1995:01	-6.498***	$\lambda = (0.40, 0.45)$	Δer_t	0	1992:04, 1994:04	-11.077***	$\lambda = (0.40, 0.45)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.13: Minimum LM Unit Root Test for Nigeria and South Africa

Table 4.13a: Nigeria Two-Breaks Minimum LM Unit Root Test for the period 1988:04 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	3	1992:03, 1995:01	-6.335***	$\lambda = (0.20, 0.40)$	Δy_t	5	1991:04, 1994:02	-8.506***	$\lambda = (0.20, 0.40)$
π_t	6	1994:01, 1997:04	-6.626***	$\lambda = (0.20, 0.34)$	$\Delta \pi_t$	7	1991:04, 1997:03	-6.894***	$\lambda = (0.20, 0.40)$
m_t	8	1993:03, 2006:04	-5.591*	$\lambda = (0.20, 0.73)$	Δm_t	7	1991:04, 1996:03	-5.197	$\lambda = (0.20, 0.40)$
i_t	2	1994:02, 2002:01	-5.268	$\lambda = (0.23, 0.547)$	Δi_t	0	1993:03, 1994:02	-11.485***	$\lambda = (0.20, 0.35)$
er_t	0	1992:01, 1998:04	-5.098	$\lambda = (0.20, 0.42)$	Δer_t	0	1998:03, 1999:02	-18.768***	$\lambda = (0.40, 0.60)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.13b: South Africa Two-Breaks Minimum LM Unit Root Test for the period 1980:01 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	2	1983:04, 2006:03	-5.482*	$\lambda = (0.20, 0.80)$	Δy_t	0	1983:03, 1985:02	-7.243***	$\lambda = (0.19, 0.20)$
π_t	7	1992:02, 2007:02	-6.440***	$\lambda = (0.34, 0.82)$	$\Delta \pi_t$	4	1994:01, 2009:01	-6.331**	$\lambda = (0.40, 0.88)$
m_t	2	1991:04, 2000:04	-5.038	$\lambda = (0.36, 0.67)$	Δm_t	7	1990:04, 1992:02	-8.029***	$\lambda = (0.30, 0.34)$
i_t	8	1984:04, 1989:02	-5.188	$\lambda = (0.20, 0.24)$	Δi_t	0	1985:02, 1989:04	-8.235***	$\lambda = (0.20, 0.30)$
er_t	3	2001:01, 2003:03	-5.637*	$\lambda = (0.63, 0.71)$	Δer_t	1	2002:03, 2006:04	-10.910***	$\lambda = (0.69, 0.81)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.14: Minimum LM Unit Root Test for Tunisia and Uganda

Table 4.14a: Tunisia Two-Breaks Minimum LM Unit Root Test for the period 1988:03 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	8	2000:04, 2004:03	-7.007***	$\lambda = (0.46, 0.63)$	Δy_t	3	2003:04, 2005:02	-13.130***	$\lambda = (0.60, 0.68)$
π_t	6	1992:01, 2000:01	-5.405*	$\lambda = (0.20, 0.48)$	$\Delta \pi_t$	3	1992:04, 1994:02	-12.759***	$\lambda = (0.20, 0.40)$
m_t	2	1993:01, 1997:04	-4.778	$\lambda = (0.20, 0.40)$	Δm_t	7	1996:04, 2002:04	-9.444***	$\lambda = (0.28, 0.55)$
i_t	5	1993:02, 2000:02	-5.883**	$\lambda = (0.20, 0.46)$	Δi_t	7	1992:03, 2001:04	-6.804**	$\lambda = (0.20, 0.51)$
er_t	8	1999:02, 2008:01	-5.536*	$\lambda = (0.40, 0.78)$	Δer_t	0	1991:02, 1998:02	-8.019***	$\lambda = (0.20, 0.40)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.14b: Uganda Two-Breaks Minimum LM Unit Root Test for the period 1982:02 - 2012:04

variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)	variable	ℓ	Break dates(TB)	LM statistic	λ (Break points)
y_t	8	1985:02, 1992:02	-7.373***	$\lambda = (0.20, 0.40)$	Δy_t	7	1985:04, 1988:01	-12.788***	$\lambda = (0.20, 0.40)$
π_t	8	1988:02, 1993:02	-7.852***	$\lambda = (0.20, 0.40)$	$\Delta \pi_t$	3	1986:03, 1990:02	-10.844***	$\lambda = (0.20, 0.25)$
m_t	6	1988:03, 1997:03	-6.064***	$\lambda = (0.20, 0.49)$	Δm_t	3	1985:04, 1989:04	-8.225***	$\lambda = (0.20, 0.40)$
i_t	3	1990:03, 1994:01	-6.733***	$\lambda = (0.26, 0.36)$	Δi_t	0	1988:02, 1993:04	-10.071***	$\lambda = (0.20, 0.36)$
er_t	8	1986:04, 1996:01	-5.522*	$\lambda = (0.20, 0.42)$	Δer_t	3	1986:04, 1992:04	-13.034***	$\lambda = (0.20, 0.32)$

Note: ℓ is the augmentation number of lagged differenced terms to account for serial correlation and λ the critical value break points.

Table 4.10 reports critical values for the break dates at the 1% (**), 5% (**) and 10% (*) significant levels respectively.

The break points depend on the location of the break dates.

Table 4.15: Summary of Structural Breaks Minimum LM Test

LS (2003) Test order of Integration						
Country	y_t	π_t	m_t	i_t	er_t	pc_t
Algeria	I(0)	I(0)	I(0)	I(1)	I(1)	I(1)
Botswana	I(0)	I(1)	I(1)	I(1)	I(1)	
Ghana	I(0)	I(0)	I(0)	I(0)	I(0)	
Kenya	I(0)	I(0)	I(1)	I(0)	I(0)	
Nigeria	I(0)	I(0)	I(0)	I(1)	I(1)	
South Africa	I(0)	I(0)	I(1)	I(1)	I(0)	
Tunisia	I(0)	I(0)	I(1)	I(0)	I(0)	
Uganda	I(0)	I(0)	I(0)	I(0)	I(0)	

Note: I is the order of integration.

Table 4.16: Algeria: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1993:02, 1997:03	Civil War (1991-1997)
π_t	1990:02, 1996:04	Election (1992), Economic reforms (1986-1998)
m_t	1986:04, 1999:04	Economic reforms (1986-1998), Elections (1999)
i_t	1994:01, 1995:02	Economic reforms (1986-1998)
er_t	1990:02, 1991:04	Currency Devaluation (1990-1998)
pc_t	2007:02, 2008:01	Financial crisis (2007-2008)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.17: Botswana: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1987:04, 1992:04	Economic Boom (1980-2006)
π_t	1992:04, 1997:01	Election (1984-1997)
m_t	1984:01, 1985:01	Economic Boom (1980-2006)
i_t	1987:03, 1990:03	Economic reforms (1980-2006)
er_t	2007:03, 2009:01	Currency devaluation (2005-2011) & Financial crisis (2007-2009)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.18: Ghana: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1984:04, 1989:03	Economic reforms (1983-1996)
π_t	1984:02, 1996:03	Economic reforms (1983-1996) & Election (1996)
m_t	1989:01, 1990:04	Economic reforms (1983-1996)
i_t	1995:02, 2005:03	HIPC initiative (1996) & Completion date (2004)
er_t	1999:02, 2005:02	Economic recession (1995-1999), Devaluation (2002-2005)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.19: Kenya: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1991:04, 1995:04	Recession (1982-1993), Economic reforms (1993-1996)
π_t	1991:04, 1994:04	Election (1992-1993), Economic reforms (1993-1996)
m_t	1984:04, 1993:02	Recession (1982-1993)
i_t	1992:02, 1994:01	Recessions (1991-1993) & Economic reforms (1993-1996)
er_t	1992:03, 1995:01	Trade liberalization (1993-1996)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.20: Nigeria: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1992:03, 1995:01	Economic reforms (1986-2006)
π_t	1994:01, 1997:04	Economic reforms (1986-2006)
m_t	1993:03, 2006:04	Economic reforms (1986-2006)
i_t	1993:03, 1994:02	Economic reforms (1986-2006)
er_t	1998:03, 1999:02	Economic reforms (1986-2006)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.21: South Africa: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1983:04, 2006:03	Election (1990), Economic reforms (2000-2006)
π_t	1992:02, 2007:02	Economic reforms (2000-2006), Recession (2007)
m_t	1990:04, 1992:02	Election (1990)
i_t	1985:02, 1989:04	Institutional frameworks (1985-1989)
er_t	2001:01, 2003:03	Currency Devaluation (1995-2003)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.22: Tunisia: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	2000:04, 2004:03	Recession (2000-2004)
π_t	1992:01, 2000:01	Economic reforms (2000-2006)
m_t	1996:04, 2002:04	SAP (1986-2006)
i_t	1993:02, 2000:02	SAP (1986-2006)
er_t	1999:02, 2008:01	Trade Liberalization (1986-2006) & Financial crises (2007- 2008)

Source: Policy Background of the sampled economies and Author's Calculation.

Table 4.23: Uganda: Timescale of Structural Breaks

Minimum LM Two - Breaks Test		
variable	Break points	Timescale of Events
y_t	1985:02, 1992:02	Economic reforms (1986-2000)
π_t	1988:02, 1993:02	Economic reforms (1986-2000)
m_t	1988:03, 1997:03	Economic reforms (1986-2000)
i_t	1990:03, 1994:01	Economic reforms (1986-2000)
er_t	1986:04, 1996:01	Economic reforms (1986-2000)

Source: Policy Background of the sampled economies and Author's Calculation.

4.10 Summary and Conclusions

This chapter has explicitly provided an empirical approach to examine the data and the issue of stationarity. The chapter centered on defining data sources, followed by a descriptive analysis of the variables. Data was analysed by conducting a series of unit root tests to examine the time-series properties of the variables. The results obtained indicate that the KPSS and LS tests perform better than the ADF and PP tests in the presence of stationarity and structural breaks with a unit root. While the ADF and PP tests find unit roots for inflation, this is insignificant with the KPSS and LS tests. The reason being that the latter tests do not suffer from spurious rejections and bias, which is common with the unit root tests. The money supply is stationary in levels using the KPSS test. These results also show that the output gap is stationary in levels for the sampled economies, while mixed findings are obtained for the interest rate and the exchange rate. This is perhaps due to the fact that these tests do not consider the time-lag between monetary policy actions and preferences in response to changes in macroeconomic variables.

This chapter offers a contribution through the modelling structural breaks within unit root tests in African monetary policy. The structural break points were endogenously determined from the DGP in order to eliminate bias that may arise in an attempt to exogenously determine the break dates. The results obtained show that the break dates correspond with the host of institutional framework changes (such as SAP and HIPC initiatives) and macroeconomic reforms which occurred in the mid-eighties and nineties. Our results are robust to the findings that the two breaks minimum LM test exhibits more power and less sample size distortion than the one break point test in the presence of structural breaks in a unit root.

An important methodological issue concerns whether to consider using levels or first differences of the variables in the monetary policy framework in the later analysis. It is quite common in this literature to consider the levels of variables in the VAR framework such as Christiano et al (1996) and Uhlig (2005), studying the effects of the U.S monetary policy transmission mechanism. Other studies such as those of Bernanke and Blinder (1992), Bernanke and Gertler (1995), Kim (1999), Kim and Roubini (2000), Kim (2001), Faust and Rogers (2003), Sousa and Zaghini (2007), Anzuini et al (2010), Catik and Martin (2012) and Sousa (2014) have estimated the VAR using the levels of non-stationary variables.¹⁴ They argue is because differencing compromises asymptotic efficiency and results

¹⁴In practice, adding sufficient lags removes the effect of non-stationarity (Uhlig, 2005).

in loss of information set according to monetary policy from the VAR model. It is also the case that differencing distort parameter values and can possibly remove long-run effects when there is interdependencies¹⁵ in the variables (Bagliano and Morana, 2003). Given that differencing has low power, in the empirical analysis, estimation is by using the levels of the variables following the prescribed literature. It is also because most of the variables appear to be stationary in levels by the KPSS test. However, the problem of structural breaks is resolved by adding dummy variables with the other tests in the next chapters, based on the dates where the breaks occurred. This also included the period when inflation targeting frameworks were introduced, in order to test whether the changes in the economy had major effects on monetary policy. The response function take the value of one for the period of the structural breaks and zero otherwise.

Having examined the policy background in the African economies as well as data and testing for stationarity, Chapter 5 proceeds with an investigation into the effectiveness of monetary policy in the African economies. The monetary policy transmission mechanism is important to determine appropriate policy actions and time-lags in monetary policy.

¹⁵Such interdependencies may include possible cointegration relationships. It is recommended not to test for cointegration on the first differences of variables.

4.11 Appendix

4.11.1 Algebraic Analysis of Data Interpolation Method

Consider a flow variable y_t , represented by the continuous function $f(t)$ and with time path, t as; $y_t = f(t)$. The realization of y_t at the end of period one accumulates in the interval 0 to 1, where $0, 1 \in \mathbb{R}$. The dynamic path of y_t can be expressed as the definite integral.

$$y_t = \int_0^1 f(t)dt \quad (4.13)$$

Interpolation is achieved by partitioning the area under the curve into quarterly observations, such that each quarter is 0.25 upper bound (Moosa, 1995). This gives:

$$y_t^i = \int_0^{0.25} f(t)dt + \int_{0.25}^{0.5} f(t)dt + \cdots + \int_{0.75}^1 f(t)dt \quad (4.14)$$

where $i = 1, 2, 3, 4$, representing each quarter of y_t . Using Simpson's (parabolic) rule in numerical integration, the dynamic path of y_t follows the quadratic form¹⁶:

$$f(t) = \eta t^2 + \gamma t + \psi \quad (4.15)$$

where η , γ and ψ are constant parameters to be estimated. The Simpson's rule approximate the definite integral, $\int_0^1 f(t)dt$ by partitioning $[0, 1]$, into the set $\{t_0, t_1 \cdots t_n\}$ where $t \in \mathbb{R}$, so that there are t sub-intervals of equal width. Unlike the Trapezoidal rule which approximates the definite integral by straight lines, the Simpson's rule takes into account the curvature of the graph, $y_t = f(t)$ to any degree of accuracy. One can infer from equation (4.15) that:

$$y_t = \int_{t-1}^t (\eta t^2 + \gamma t + \psi)dt \quad (4.16)$$

and $t - 1 < t$. Further assume that y_{t-1} , y_t and y_{t+1} are three successive annual observations¹⁷ of $f(t)$. Therefore, for $t = 1, \cdots 3$, the quadratic function y_t passing through the three points can be approximated by the following definite integrals using equation (4.16) as:

$$\begin{aligned} y_1 &: \int_0^1 (\eta t^2 + \gamma t + \psi)dt = y_{t-1} \\ y_2 &: \int_1^2 (\eta t^2 + \gamma t + \psi)dt = y_t \\ y_3 &: \int_2^3 (\eta t^2 + \gamma t + \psi)dt = y_{t+1} \end{aligned} \quad (4.17)$$

The solutions to the above definite integrals give the following values for η , γ and

¹⁶A quadratic form is chosen to derive all properties of approximation with accuracy (Wymer, 2012).

¹⁷See Goldstein and Khan (1976).

ψ .

$$\begin{aligned} 0.50y_{t-1} - 1.00y_t + 0.50y_{t+1} &= \eta \\ -2.00y_{t-1} + 3.00y_t - 1.00y_{t+1} &= \gamma \\ 1.833y_{t-1} - 1.167y_t + 0.333y_{t+1} &= \psi \end{aligned}$$

This is expressed in matrix form for notational convenience as:

$$\begin{bmatrix} 1/2 & -1 & 1/2 \\ -2 & 3 & -1 \\ 11/6 & -7/6 & 1/3 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_t \\ y_{t+1} \end{bmatrix} = \begin{bmatrix} \eta \\ \gamma \\ \psi \end{bmatrix} \quad (4.18)$$

Let y_t^i , denote observation of the quarter, of length 0.25. Using the values of η , γ and ψ , quarterly series are obtained by evaluating the following definite integrals for each sub-quarter (Q_1, Q_2, Q_3 and Q_4).¹⁸

$$y_t^i = \int_{t_1}^{t_2} (\eta t^2 + \gamma t + \psi) dt$$

$$y_t^1 : \int_{1.00}^{1.25} (\eta t^2 + \gamma t + \psi) dt = Q_1 \quad (4.19)$$

$$y_t^2 : \int_{1.25}^{1.50} (\eta t^2 + \gamma t + \psi) dt = Q_2 \quad (4.20)$$

$$y_t^3 : \int_{1.50}^{1.75} (\eta t^2 + \gamma t + \psi) dt = Q_3 \quad (4.21)$$

$$y_t^4 : \int_{1.75}^{2.00} (\eta t^2 + \gamma t + \psi) dt = Q_4 \quad (4.22)$$

Solving equations (4.19 - 4.22) and using equation (4.18), gives the following equations for interpolating annual observations into the corresponding quarterly data series.

$$\begin{aligned} 0.0547y_{t-1} + 0.2344y_t - 0.0391y_{t+1} &= Q_1 \\ 0.0078y_{t-1} + 0.2656y_t - 0.0234y_{t+1} &= Q_2 \\ -0.0234y_{t-1} + 0.2656y_t + 0.0078y_{t+1} &= Q_3 \\ -0.0391y_{t-1} + 0.2344y_t + 0.0547y_{t+1} &= Q_4 \end{aligned}$$

$$\begin{bmatrix} 0.0547 & 0.2344 & -0.0391 \\ 0.0078 & 0.2656 & -0.0234 \\ -0.0234 & 0.2656 & 0.0078 \\ -0.0391 & 0.2344 & 0.0547 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_t \\ y_{t+1} \end{bmatrix} = \begin{bmatrix} Q_1 \\ Q_2 \\ Q_3 \\ Q_4 \end{bmatrix} \quad (4.23)$$

¹⁸The lower interval, $t_1 = 1.00$ to take into account the frequency of the annual data series.

The interpolation technique is validated by summing up the weights for each quarter. This gives 0.25, such that the vertical summation for all the quarters equals one; is exactly approximated to the corresponding annual observations.

4.11.2 Testing Robustness of the Interpolation technique

The interpolation method is further validated by considering the annual series for the log of real GDP for the South African economy, which is the largest economy in Africa, to generate quarterly series and tested against a much larger economy such as that of the United States. This is to establish if similar results could be obtained from both series. The data for both countries was obtained from the IFS of the IMF. The statistical properties of the original (annual) and generated quarterly series are reported in Table 4.24. The results indicate that both series have similar qualitative properties which is an indication that the quarterly series for the real GDP are approximated with high accuracy to that of the original annual series. Figure 4.1 illustrates the graphs of the annual data and the generated quarterly series for both countries.

The graphical analysis suggests that the two series follow similar patterns¹⁹. As an original contribution to the thesis, we have provided a generic method for interpolating low frequency series to high frequency data. This has been tested to produce the same trend for generating monthly data from annual data series (although monthly data has not been used in this thesis).

¹⁹This is similar to the real GDP series by the Federal Reserve Bank of St Louis, accessed at <http://research.stlouisfed.org/fred2/graph/?id=GDPC1>

Table 4.24: Annual and Quarterly Time-series: Descriptive Statistics for South Africa and the U.S: 1980 - 2012

Annual Real GDP			Quarterly Real GDP		
	South Africa	United States		South Africa	United States
Mean	9.43	4.57	Mean	9.43	4.57
Median	9.37	4.57	Median	9.37	4.57
Minimum	9.14	4.09	Minimum	9.12	4.09
Maximum	9.88	4.95	Maximum	9.89	4.97
SD	0.23	0.28	SD	0.23	0.28
Skewness	0.58	-0.21	Skewness	0.58	-0.21
Kurtosis	1.95	1.71	Kurtosis	1.95	1.71
T	33	33	T	132	132

Note: SD indicates the standard deviation of the series while T is the sample size.

The mean, SD, skewness and kurtosis are the same for both series.

Results are obtained using the RATS software.

Fig: Annual Real GDP Series

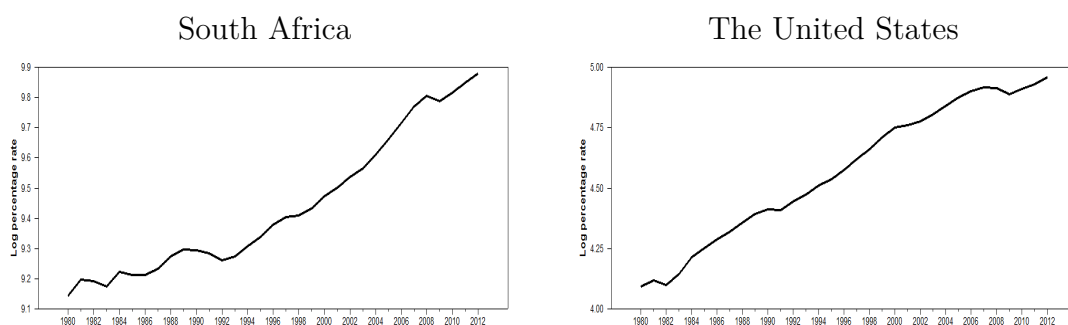


Fig: Quarterly Real GDP Series

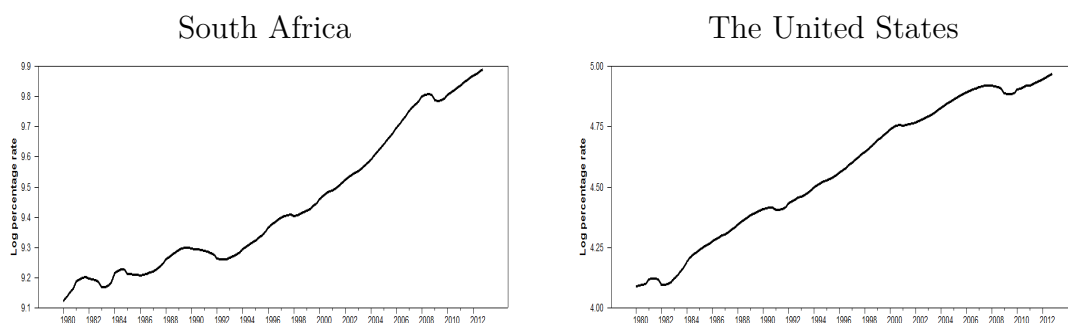


Figure 4.1: Real GDP Time-series graphs for South Africa and the United States.

4.11.3 Data Description

The dataset used in this thesis includes seasonally adjusted (using the Census X12 approach) for the following sets of macroeconomic variables.

Table 4.25: Summary (brief definitions) of the Data

Variable	Definition
y_t	The output gap is the detrended series of the log of real GDP which is deflated by the CPI, using the HP filter. The output gap has been used to provide a measure of movements in the business cycle. Data for the GDP was sourced from the IFS and WDI.
π_t	Inflation is measured as the annualized rate of change of the CPI between two subsequent quarters. Data for the CPI were obtained from the IFS.
m_t	The money supply variable is measured in terms of the growth rate in the broad money supply, obtained from the WDI.
pc_t	Measured as the year-on-year rate of change of commodity food price index, representing changes in information sets according to monetary policy. Data was obtained from the IFS.
i_t	The Central Bank's short-term nominal interest rate, was taken from the IFS, to reflect changes in monetary policy framework.
er_t	The nominal effective exchange rate is defined as the national currency per units of foreign currencies which are the SDR. The basket of foreign currencies is dominated by the U.S. Dollar, the Euro, British Pound Sterling and the Japanese Yen. Data was sourced from the IFS.

Note: IFS and WDI = are taken from the IMF and WB databases respectively.

Chapter 5

An Investigation of the Effectiveness of Monetary Policy in a sample of African economies

5.1 Introduction

This chapter examines the appropriate policy response of the monetary policy transmission mechanisms in a sample of African economies in order to investigate the effectiveness of the monetary policy instruments in maintaining macroeconomic stability. The lack of economic growth (compared to the rest of the World) in most of Africa's economies until recently has become an increasingly popular area of research, as attempts are made to determine why the performance has been below expectations, which were output growth, price and exchange rate stability. There is little empirical studies that focuses on the transmission mechanism of monetary policy shocks in small open economies, such as those of the African economies. This is perhaps explained by the fact that monetary policy became effective in the last few decades, following episodes of high inflation and negative output growth that occurred in the 1980's. This chapter concentrates on the monetary side of the economy, as a potential area that could explain the levels of development and general performance of the wider economy.

The chapter concurs with the theoretical and empirical review on the identification of the SVAR in Chapter 2, which is driven by the following research question: how effective are monetary policy instruments in the African economies? In order to answer this research question we employ, the SVAR approach to analyse the impact of the monetary policy innovations on the real economy. The aim is to quantify how shocks, in the short-term nominal interest rate, the broad

money supply and the exchange rate, affect the non-policy variables such as the output gap and inflation. The dynamics of monetary policy are captured by the IRF to ascertain the degree of asymmetry of the monetary policy shocks to the real economy. The application of this method in the context of the African economies has been limited so far, which motivates our line of research in order to determine if similar inference to that of developed countries can be established.

The remainder of the chapter proceeds as follows. Following the introduction, section 5.2 addresses the methodology, encompassing the VAR model and optimal lag order in section 5.3. This is followed by the structural identification scheme in section 5.4 while section 5.5 introduces data and the empirical model. Section 5.6 explores the theoretical framework pertaining to the empirical model. Section 5.7 presents and discusses the empirical results. Firstly, we explain the intuition behind the contemporaneous coefficients in the structural model. Secondly, the SVAR results are explained in terms of the dynamics of the impulse responses and the FEVD in section 5.8. Section 5.9 highlights robustness checks which consider the departure from the benchmark model while the conclusions and policy implications are discussed in section 5.10.

5.2 The VAR Model

The conclusions drawn from the policy background chapter on the African economies suggest that different policy instruments were implemented in different countries. Therefore, targeting a particular variable is unrealistic given the interaction between the non-policy variables, the output gap and inflation, and the policy variables, the broad money supply, the short-term interest rate and the exchange rate. This section introduces the VAR method, which is commonly used in the literature to analyse the transmission mechanism of the monetary policy shocks.

The empirical model considers a (5×1) vector of endogenous policy and non-policy variables, z_t , consisting of the quarterly time-series data for the output gap (y_t), the inflation rate (π_t), the broad money supply (m_t), the short-term nominal interest rate (i_t) and the nominal effective exchange rate (er_t) such that; $z_t = [y_t, \pi_t, m_t, i_t, er_t]'$. We estimate a p^{th} – dimensional reduced form VAR model in describing the moments of the data as:

$$z_t = B_0 + B_1 z_{t-1} + B_2 z_{t-2} + \dots + B_p z_{t-p} + \varepsilon_t \quad (5.1)$$

where, B_0 is a 5×1 vector of constants, B_1, \dots, B_p , are the (5×5) coefficient matrices. The lag length p is determined by the Hannan and Quinn (1979) information criterion (HQIC), has been defined in the next section. $\varepsilon_t = [\varepsilon_t^y, \varepsilon_t^\pi, \varepsilon_t^m, \varepsilon_t^i, \varepsilon_t^{er}]'$ is a 5×1 vector of the contemporaneous error terms associated with each of the variables in the system is assumed to be uncorrelated.

The arrangement of the variables in z_t follows similar approach in the literature as in Starr (2005) and Kalyvitis and Michaelides (2001), based on the assumption that the output gap adjusts more sluggishly than inflation and changes in the interest rate. This is an iteration from studies on industrialized economies, where it is assumed that price rigidity leads to a delayed impact from inflation on the macroeconomic variables (Christiano et al, 2005). The sticky price model which is developed by Mankiw and Reis (2002) suggests monetary policy affects the real economy in the short-run with a delayed impact on prices, following a Calvo (1983) type staggered price setting. Monetary policy affects prices in the long-run due to sticky price information, implying a cost of gathering information which only slowly disseminates to the wider economy (Mankiw and Reis, 2002). In the case of developing economies, prices are flexible to adjust towards equilibrium. This is due to market competition resulting from variability in aggregate demand shocks¹ which affects prices while nominal rigidities stem from output through production methods (Kandil, 2008). The money supply is placed before the interest rate to reflect the fact that the monetary authorities choose the policy rate after observing the growth rate in the money supply² (Davoodi et al, 2013).

5.3 Optimal Lag Order and Convergence Criteria

The lag length is chosen to determine the correct order of the underlying DGP. According to Liew (2004) and Lutkepohl (2005) the AIC performs well in small sample ($T < 60$), as it chooses the correct order of the variables.

$$AIC = T \log |\Sigma| + 2k \quad (5.2)$$

where, $|\Sigma|$ is the determinant of the variance-covariance matrix of the residuals,

¹These are identified as unanticipated shocks that temporarily increase or decrease prices of goods and services as a result of changes in consumer preference or their relative prices.

²Also see the McCallum (1983) critique that interest rate explains unanticipated monetary policy shocks better than innovations in the money supply.

k , the number of parameters in all equations and T indicates the sample size (Enders, 2010). Although the AIC has proven popular, it could be biased towards selecting an over-parameterized model (Enders, 2010). To address this pitfall, we consider the Schwarz (1978) Bayesian information criterion (SBIC) and HQIC of model selection which are based on large samples, if consistency is used as a yardstick to determine the correct order of the variables.

$$SBIC = T \log | \Sigma | + k \log(T)$$

$$HQIC = T \log | \Sigma | + 2k \log(\log(T))$$

Kilian and Chang (2000) and Kilian and Ivanov (2005) employed mean-squared error methods (based on simulations) to describe the accuracy of IRF and found that HQIC is the most suitable lag length criterion for quarterly data with a large sample size, $T > 120$ and the SBIC will deliver the correct model for any sample size less than 120 observations.³

Assuming that the VAR model in equation (5.1) is stable, the reduced form matrix can be inverted into its Wold form moving average (MA) representation as; $z_t = \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i}$. Where ε_t is a white noise error term defined in equation (5.1) and ϕ_i represents the inverse roots of the AR polynomial matrix. This means that the eigenvalues are lying inside the unit root circle of ϕ_i (covariance stationary process) and have modulus less than unit (Lutkepohl, 2005). Following the approach developed by Godfrey (1988), we estimated the multivariate LM test for the i^{th} order residual autocorrelation as: $\varepsilon_t = \phi_1 \varepsilon_{t-1} + \dots + \phi_i \varepsilon_{t-i} + \mu_t$, where μ_t is white noise under the null hypothesis that, $H_0 : \phi_1 \dots \phi_i = 0$, of no serial autocorrelation.⁴ The LM statistic is, $LM = TR^2 \sim \chi^2(k^2)$, has an asymptotic chi-square distribution with k^2 degrees of freedom, where T is the sample size, while R^2 measures the coefficient of determination. These results for the different lag selections are represented in Table 5.1, where $PV[LMA]$ is the multivariate LM test probability value for the null of no serial correlation, tested at the 5% level.

³The modified versions of these information criteria are: $MAIC = \log | \Sigma | + 2\frac{k}{T}$; $MSBIC = \log | \Sigma | + \frac{k}{T} \log(T)$ and $MHQIC = \log | \Sigma | + 2\frac{k}{T} \log(\log(T))$.

⁴The auxiliary regression model is: $\hat{\varepsilon}_t = B_0 + B_1 z_{t-1} + B_2 z_{t-2} + \dots + B_p z_{t-p} + \phi_1 \hat{\varepsilon}_{t-1} + \dots + \phi_i \hat{\varepsilon}_{t-i} + \mu_t$

Table 5.1: Optimal Lag Length Selection of the VAR Model

	AIC	SBIC	HQIC	PV[LMA]
Algeria	2	2	2	0.850**
Botswana	2	1	2	0.069**
Ghana	5	5	5	0.520**
Kenya	6	5	6	0.649**
Nigeria	2	2	2	0.175**
South Africa	2	1	2	0.169**
Tunisia	2	2	2	0.200**
Uganda	6	6	7	0.354**

Note: ** means no autocorrelation at the 5% level

Results are obtained using the Eviews software.

The optimal lag length⁵ has been determined by the HQIC following the study of Kilian and Ivanov (2005), with two lags to ensure its stability of the VAR model such that no root lies outside the unit circle.⁶ Although the information criteria chooses different lag lengths, the VAR model is stable with two lags which is quite convincing for a dataset spanning 132 observations. The essence of VAR stability (synonymously referred to as convergence criteria) is to determine the correct order of the VAR model. This helps us to derive a valid analysis of the IRF, in accordance with the stationarity conditions; constant means, variances, co-variances and being time-invariant. Further diagnostic checks indicate that autocorrelation in the model's residuals is insignificant at the 5% level. Given that the VARs are atheoretical, a structural (identified VAR) model is used to recover forecast errors from the reduced form VAR model without an "a priori" knowledge of the impulse responses.

5.4 The Structural Identification Scheme

According to Lutkepohl (2005), the least squares VAR estimates are of little importance themselves especially when the objective is to study the effect of monetary policy shocks on the economy. We rewrite the model in equation (5.1) to consider its structural form representation, which excludes the constant term for the sake of notational convenience as:

$$Bz_t = B_1z_{t-1} + B_2z_{t-2} + \cdots + B_pz_{t-p} + v_t \quad (5.3)$$

⁵Kim and McMillin (2003) used Monte Carlo simulations and concluded that the lag length do not matter when assessing the impact of monetary policy shocks.

⁶Starr (2005) estimated a VAR model, with five variables, using two lags for four transition economies (Russia, Ukraine, Kazakhstan and Belarus).

Where, B is a $(k \times k)$ matrix linking the residuals with the structural innovations, B_1, \dots, B_p , are (5×5) matrices of contemporaneous coefficients of the variables, with elements B_{ij} . Multiplying both sides of equation (5.3) by the inverse of B gives:

$$z_t = B^{-1}B_1z_{t-1} + B^{-1}B_2z_{t-2} + \dots + B^{-1}B_pz_{t-p} + \varepsilon_t \quad (5.4)$$

where $\varepsilon_t = B^{-1}v_t \iff B\varepsilon_t = v_t$. The observed structural errors ($\varepsilon_{t's}$) are uncorrelated white noise (Gaussian) terms relative to past realizations of z_t . This means, $\varepsilon_t \sim i.i.d(0, \Sigma_u)$ is assumed to be linear and identically independent with zero mean, $E(\varepsilon_t) = 0$ and having a positive definite co-variance matrix (Σ_u) of the residuals (Lutkepohl, 2005).

The identifying restrictions are placed on matrix B such that $B\varepsilon_t = v_t$ has a unit diagonal matrix $E(\varepsilon_t\varepsilon_t') = \Sigma_u$, with the variance $\sigma^2(\varepsilon_{t's}) = I_m$ and the covariance of the residuals equals zero, $cov(\varepsilon_t^\tau \varepsilon_t^j) = 0$, for $\tau \neq j$. This approach follows Kalyvitis and Michaelides (2001) and Enders (2010). It follows that the relationship between the unobserved shocks and the observed shocks is given as:

$$B\varepsilon_t = v_t \quad (5.5)$$

where $v_t = [v_t^{as}, v_t^{ad}, v_t^{md}, v_t^{ms}, v_t^{bop}]'$ is a 5×1 vector of unobserved shocks, arising from the aggregate supply (v_t^{as}), aggregate demand (v_t^{ad}), money demand (v_t^{md}), money supply (v_t^{ms}) and the balance of payments (v_t^{bop}) respectively. The unobserved errors are specified as linear functions of the reduced form residuals (observed shocks) through macroeconomic shocks. However, B (with elements β_{ij} , as represented in equation (5.6) contains $\frac{1}{2}k(k+1)$ unknown parameters in the k^2 system, where k is the number of variables. Intuition suggests that by subtracting $\frac{1}{2}k(k+1)$ from k^2 gives an expression for the total number of restrictions, where $k^2 = \frac{1}{2}k(k+1) + \frac{1}{2}k(k-1)$. Additional restrictions, of $\frac{1}{2}k(k-1)$ are required to satisfy the non-recursive identification, which is based on section 5.5 below. This local identification (order condition) was first proposed by Rothenberg (1971), in contrast to other studies which have imposed global identification (Rubio-Ramirez et al, 2010).

5.5 Data and the Empirical Model

The data set includes quarterly data from 1980:01 to 2012:04 consisting of 132 observations for the real GDP, consumer prices, a commodity price index, the money supply, policy interest rate and the exchange rate. The output gap is the detrended series of the log of real GDP using the HP filter. All data series

are transformed into their growth rates, excluding non-trending series such as the interest rate. Data was sourced from the IFS and WDI, of the IMF and World Bank databases respectively for Algeria, Botswana, Ghana, Kenya, Nigeria, South Africa, Tunisia and Uganda. These are countries with a relatively large GDP and with a strong emphasis on monetary policy to reduce inflation to target levels and increase output.

We considered the following empirical model based on the monetary policy frameworks of these economies, which includes the policy and non-policy variables. The method employed here follows Kim and Roubini (2000) who use a non-recursive identification approach based on economic theory, which is a generalization of the Sims and Zha (1999) model. The advantage of this approach is that it produces results which are tenable with the theory, unlike the recursive assumption (which is otherwise known as the Cholesky decomposition⁷) which is not based on economic theory (Sim and Zha, 1999; Mishra and Montiel, 2012). This is to say that the recursive assumption imposes restrictions on all off-diagonal elements of B , (from $B\varepsilon_t = v_t$) without economic theory. The implication of the non-recursive assumption suggests that non-policy variables respond contemporaneously to the policy variables (Sims and Zha, 2006).

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} & 0 \\ 0 & 0 & \beta_{43} & 1 & \beta_{45} \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^\pi \\ \varepsilon_t^m \\ \varepsilon_t^i \\ \varepsilon_t^{er} \end{bmatrix} = \begin{bmatrix} v_t^{as} \\ v_t^{ad} \\ v_t^{md} \\ v_t^{ms} \\ v_t^{bop} \end{bmatrix} \quad (5.6)$$

The standard approach in the literature is to assume that the exchange rate reacts immediately to all shocks, but due to nominal rigidities, there is a slow process for the exchange rate pass-through to macroeconomic variables (Bjornland, 2009). This is plausible for the African economies due to their monetary policy consisting of an exchange rate policy dominated macroeconomic frameworks. The literature also assumes that the output gap and inflation (non-policy variables) do not contemporaneously affect the monetary policy variables. The money supply shock is more directly related to output and prices (Christiano et al, 1999). These assumptions underpin the basis for the empirical model and are also based on the theoretical analysis in the next section.

⁷By recursiveness assumption, the reduced form innovation in the first variable ordered in the VAR is structural while that in the second variable is a structural innovation in addition to the contemporaneous innovation in the first variable (Christiano et al, 1996 and Mishra and Montiel, 2012).

5.6 Theoretical Implications of the Identifying Restrictions

The identified VAR model in equation (5.6) is estimated, based on a theoretical framework for the underlying economies. This section provides an insight into the theoretical relationship between the macroeconomic variables and the monetary policy shocks, to reflect the NKM (as evidenced by Gali, 2008; Svensson, 2000 and Clarida et al, 1999). The first of these analyses is the aggregate supply shock assuming a small open economy.

5.6.1 The Aggregate Supply Shock

The aggregate supply shock arises from the augmented Phillips curve by introducing nominal inertia (persistence) in the form of expected future inflation (π^e). We assume that current inflation (π_t) depends on π^e , the output gap ($y_t - \bar{y}$) and a supply shock⁸ (s_t). This relationship can be expressed as:

$$\pi_t = \pi^e + \alpha(y_t - \bar{y}) + s_t \quad (5.7)$$

where, α , measures the sensitivity of the output gap (slope of the Phillips curve). Under rational expectations, $\pi_t = \pi^e$ and $(y_t - \bar{y}) = \varepsilon_t^y$, which are innovations to the output gap if expectations are fulfilled (De Arcangelis, 1996).⁹ This implies that the long-run aggregate supply curve (LRAS) is vertical and the monetary policy shocks have no long-run effect on the output gap. A shift in the short-run aggregate demand curve increases the price level (proportionately) but not the output gap. Specifically, this is embodied by the following long-run restrictions on the output gap in equation (5.6). Firstly, $\beta_{12} = 0$, implied by the natural rate hypothesis that demand shocks have no long-run impact on the output gap (BQ and Cover et al, 2006). Secondly, $\beta_{13} = 0$, $\beta_{14} = 0$ and $\beta_{15} = 0$ implying that the broad money supply,¹⁰ the interest rate and the exchange rate do not contemporaneously (instantaneously) affect the output gap (which is the long-run monetary policy neutrality hypothesis (Kim, 1999 and Aksoy et al, 2005)). Hence, innovations to the output gap, equals the aggregate supply shock, $\varepsilon_t^y = v_t^{as}$.

⁸This is a shock to the Phillips curve (Orphanides and Wilcox, 2002).

⁹The intuition is that, if actual output equals potential output, such that full employment level equals expected output, then, innovations to output equals the output gap (at the steady state equilibrium).

¹⁰This is the veil of money assumption that the output gap is not influenced by the money supply.

5.6.2 The Aggregate Demand Shock

In order to incorporate the fact that the exchange rate plays an implicit role in the monetary policy framework of the African economies, we model the impact of the exchange rate on the aggregate demand using the Dornbusch (1976) type approach. Let $(\psi + p^f - p)$ denote the real exchange rate, where, p^f is the foreign price level and p the domestic price level while the nominal exchange rate is represented by ψ . Assuming that foreign prices are constant, based on the Law of one price, then, the real exchange rate is $(\psi - p)$. It is further assumed that the aggregate demand shocks are restricted only to those of monetary policy without any fiscal policy implications. With this framework in mind, the IS curve is expressed as:

$$y_t = -\delta(i_t - \pi^e) + \eta(\psi - p) + d_t \quad (5.8)$$

where, y_t is the output gap, as defined above, δ is the slope of the IS curve¹¹ and i_t is the short-term nominal interest rate at time, t . Equation (5.8), depicts an inverse relationship between the output gap and the real interest rate $(i_t - \pi^e)$. The aggregate demand shock is captured as an inflation shock. The restrictions are $(\beta_{23} = 0, \beta_{24} = 0$ and $\beta_{25} = 0)$, and are implied by the long-run neutrality of monetary policy innovations such that:

$$\varepsilon_t^\pi + \beta_{21}\varepsilon_t^y = v_t^{ad} \quad (5.9)$$

5.6.3 The Money Demand Shock

The literature assumes that the exchange rate is exogenously determined, such that the LM¹² curve equation which is identified as a money demand shock is allowed to respond contemporaneously to shocks to the output gap, inflation, real money balances and the opportunity cost of money, which is the short-term interest rate (Kim, 1999). Keynesians proposed that the demand for real money balances (m^d/p) is positively related to the output gap (measuring changes in the real economy) and negatively associated with the interest rate.

$$\frac{m^d}{p} = L(y_t, i_t) \quad (5.10)$$

This is to say that the transactions and the precautionary motives for holding money depends on the output gap, while the speculative motive depends on the interest rate, such that monetary influences shifts the LM curve. This gives the following identity for the money demand shock.

$$\varepsilon_t^m + \beta_{31}\varepsilon_t^y + \beta_{32}\varepsilon_t^\pi + \beta_{34}\varepsilon_t^i = v_t^{md} \quad (5.11)$$

¹¹ δ is negative to reflect the intertemporal substitution of consumption (interest elasticity) by individual consumers (Clarida et al, 1999; Walsh, 2010).

¹²This is defined as the output and interest rate combinations that brings equilibrium in the money market.

5.6.4 The Money Supply Shock

The money supply shock is exogenously determined and its expressed as the central bank's reaction function to innovations in the short-term interest rate (Berument, 2007). The stylized facts drawn from the policy background chapter suggests that monetary targeting was used by most of the African economies in the early 1990's, as well as maintaining stable exchange rates, while the short-term nominal interest rate played an intermediary role. This follows the Svensson (1997) and Zhang (2009) analysis that the interest rate is an important determinant for the transmission mechanism of monetary policy shocks. We model the reaction function of the central bank (after observing innovations in the interest rate, the broad money supply and the exchange rate) as follows.

$$\varepsilon_t^i + \beta_{43}\varepsilon_t^m + \beta_{45}\varepsilon_t^{er} = v_t^{ms} \quad (5.12)$$

The implication is that monetary policy responds with a lag to non-policy variables, which are the output gap ($\beta_{41} = 0$) and inflation ($\beta_{42} = 0$). This suggest that the central bank cannot observe unexpected changes in the output gap and inflation within the same period due to the time-lag in monetary policy¹³ but sets the interest rate after observing the money demand shock and the shock from commodity prices (Kim, 2001).

5.6.5 The Exchange Rate Shock

In a small open economy, like those of the African economies, net exports and capital account balances are important for the determination of the exchange rate. It is further assumed that markets are efficient by using all available information to determine the exchange rate.¹⁴ This gives the following expressions for the balance of payments shock:

$$\epsilon_t^{bp} = \begin{cases} \varepsilon_t^y, & (\varepsilon_t^{er} - \varepsilon_t^\pi) = xm_t, \\ \varepsilon_t^i, & \varepsilon_t^m = kb_t \end{cases} \quad (5.13)$$

where net exports (xm_t) depends on innovations to the output gap and the real exchange rate ($\varepsilon_t^{er} - \varepsilon_t^\pi$) plus a net capital account balance (kb_t) which is related to innovations in the money supply and the short-term interest rate. This gives the following expression for the exchange rate shock.

$$\beta_{51}\varepsilon_t^y + \beta_{52}\varepsilon_t^\pi + \beta_{53}\varepsilon_t^m + \beta_{54}\varepsilon_t^i + \varepsilon_t^{er} = v_t^{bop} \quad (5.14)$$

¹³This is a common assumption in the literature that using quarterly and monthly data series as opposed to annual data, there is usually a time-lag in monetary policy. See Anzuini et al (2010), Kim and Roubini (2000) and Starr (2005) for more details.

¹⁴The intuition is that net export captures external shocks on the balance of payments, while capital account balance reacts to innovations to short-term nominal interest rate.

The nominal effective exchange rate responds immediately to all other variables while the interest rate is placed before the exchange rate (Bjornland, 2009; Davoodi et al, 2013).

5.6.6 Commodity price shock

In the empirical model, given in equation (5.6), we replace v_t^{md} with v_t^{pc} in Algeria and Botswana. It includes an index of world commodity food prices instead of the money stock to capture inflationary pressures and its information set is relevant for monetary policy. The review of the policy background on Algeria and Botswana, suggests that fluctuations in inflation are explained by commodity price shocks. The case of Botswana may be due to the inflation-pass through effects from South Africa, which is a major trading partner with Botswana. That is to say, including commodity prices controls for negative supply shocks and inflationary pressures (Kim and Roubini, 2000). This approach has been adopted because using commodity prices produced results which are robust than those obtained using the money supply variable through the variance decompositions.

The implication is that monetary policy responds after observing shocks to commodity prices, which is reasonable for most commodity dependent economies such as Algeria and Botswana.

$$\beta_{31}\varepsilon_t^y + \beta_{32}\varepsilon_t^\pi + \beta_{34}\varepsilon_t^i + \varepsilon_t^{pc} = v_t^{pc} \quad (5.15)$$

This approach follows the analysis of Sousa and Zaghini (2007) and Sousa (2014) that commodity prices represent an information set for monetary policy. Other studies in favour of including commodity prices in the VAR model include; Sims (1992), Gordon and Leeper (1994) and Sims and Zha (2006) to eliminate the effect of the so called “price-puzzle”.

5.7 Empirical Results

5.7.1 Observed Coefficients in the Structural Model

Our analysis begins with the monetary policy implications of shocks to commodity price, the exchange rate and the money supply on the monetary authorities. The estimated coefficients in the structural model are based on the estimation of equation (5.6). These are estimated using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) non-linear estimation technique as described in Press et al (2007) for the structural parameters. Table 5.2 reports the estimated coefficients in the structural model for the African economies for the period 1980:01 to 2012:04. Figures

in parentheses are the corresponding standard errors. In Algeria and Botswana, the impact of commodity prices on the interest rate (β_{43}) is negative, implying that monetary policy reacts to unanticipated changes in commodity prices. In particular, the central bank adopts a tight monetary policy framework by raising the short-term interest rate when observing an unexpected increase in commodity prices. These results are indicative of the fact that commodity prices signal information to the central bank when conducting monetary policy and therefore validate its inclusion in our empirical model.

The results show that the impact of the money supply (β_{43}) and the exchange rate (β_{45}) coefficients on monetary policy is negative for Ghana, Kenya, Tunisia and Uganda. The implication is that monetary policy adopts a counter position when it observes unanticipated changes in the money supply and an unexpected depreciation (negative shock) of the exchange rate. These results are consistent with the CBT's monetary growth as well as the BoU's de jure monetary targeting framework. In South Africa, monetary policy takes more contractionary measures when faced with inflationary pressures from an unexpected depreciation of the exchange rate. This is reflected in the negative coefficient for the impact of the exchange rate on the interest rate. Results in Nigeria suggest that an unexpected appreciation in the exchange rate and a decrease in monetary aggregates are followed by a reduction of the policy rate (a negative monetary policy shock). These results illustrate the fact that the exchange rate plays an implicit role in the monetary policy frameworks of the African economies. This requires the central banks to tighten monetary policy when there is concern that depreciating exchange rates could lead to inflationary tendencies.

Table 5.2: Observed Coefficients in the Structural Models

	Algeria	Botswana	Ghana	Kenya	Nigeria	South Africa	Tunisia	Uganda
β_{21}	123.05** (12.22)	-14.09 (8.70)	121.02** (17.79)	82.65** (8.69)	17.81 (9.17)	23.51 (17.51)	0.07 (0.08)	124.89** (19.38)
β_{31}	184.08 (159.96)	-136.09 (159.69)	0.03 (5.26)	-5.01 (4.55)	-5.93** (2.48)	0.91 (30.99)	-0.02 (0.07)	4.32 (2.98)
β_{32}	1.51 (1.04)	-0.28 (0.66)	-0.03 (0.04)	0.01 (0.03)	0.03 (0.02)	0.045 (0.093)	-0.09 (0.29)	-0.01 (0.03)
β_{34}	6.03 (6.60)	30.29 (40.48)	1.62 (2.50)	0.79 (0.97)	-0.14 (0.27)	-0.330 (1.19)	10.81 (20.12)	0.316 (0.31)
β_{43}	-0.09 (0.18)	-0.41 (0.63)	-7.40 (15.10)	-0.41 (0.74)	0.91 (4.08)	1.69 (5.78)	-0.48 (4.18)	-1.76 (2.16)
β_{45}	47.31 (116.45)	4.90** (1.92)	-153.59 (602.04)	-14.00 (17.57)	50.42 (124.34)	-6.29 (10.57)	-3.86 (24.43)	-21.69** (7.48)
β_{51}	-1.46 (1.74)	1.67 (3.56)	0.05 (0.10)	0.34 (0.40)	1.68 (1.67)	-64.33 (61.25)	-0.002 (0.006)	-0.63** (0.26)
β_{52}	-0.01 (0.008)	0.02 (0.03)	0.0003 (0.0005)	0.001 (0.002)	0.005 (0.004)	-0.049 (0.35)	-0.017 (0.014)	-0.005** (0.001)
β_{53}	0.009 (0.014)	0.026 (0.03)	-0.02 (0.05)	-0.03 (0.07)	-0.08 (0.176)	2.77 (6.86)	-0.028 (0.039)	-0.075** (0.019)
β_{54}	-0.097 (0.099)	-0.13 (0.21)	0.001 (0.005)	0.04 (0.02)	-0.132 (0.07)	1.60 (2.69)	0.37 (0.99)	0.022 (0.019)

Note: ** indicates significance at the 5% level.

Estimation is by BFGS method for the structural parameters, using the RATS software.

5.7.2 Structural VAR Results

The transmission mechanism for the monetary policy shocks is analysed using the IRF to capture the dynamic path of the economy and the FEVD to assess the relative contribution of each structural shock. Figures 5.1 to 5.4 show impulse responses for 24 quarters¹⁵ to a one SD positive shock to the interest rate. These are derived through Monte Carlo simulations with 500 draws¹⁶ and 0.16

¹⁵Considering the short-to-medium term impact of a monetary contraction.

¹⁶Monte Carlo Integration is preferred to Bootstrapping (re-sampling of the data and therefore, loss of degrees of freedom) because it provides more efficient properties of the IRF, based on the assumption of normal likelihood of the residuals. On the contrary, the delta method applies to situations of maximum likelihood estimation. See Lutkepohl (1990) for a detailed analysis of the asymptotic properties of the delta method for IRF.

and 0.84 percentile bands.¹⁷ These results are presented for each country, where the middle line shows the impact of a shock, with the confidence interval bands. The legends are, the vertical axis represents the magnitude of the shock from monetary policy to each of the variables, while the horizontal axis is the period after the shock from monetary policy. The effect of monetary policy is manifested through an increase in the short-term interest rate above zero. This is to say that the positive monetary policy shock is a rise in interest rate.

We first analyse the impact of a positive monetary policy shock on the real domestic variables which are the output gap and inflation. In response to a rise in interest rate, the output gap falls in all countries. In Algeria, Ghana, Kenya and Nigeria the output gap falls gradually and reaches its minimum between 2 to 3 quarters after the shock to monetary policy. In the medium-to-long term, the output gap returns to zero after 8-12 quarters, following the contemporaneous period of the shock. The response of a monetary policy shock to the output gap is persistent in Botswana and South Africa. The output gap falls rapidly below zero, reaching its minimum after between 4-9 quarters but eventually returning to equilibrium after 20-22 quarters. In Tunisia and Uganda, the output gap decreases gradually from the period contemporaneous to the shock to the monetary policy. These results are consistent with the literature that the response of the output gap after a monetary contraction is slow (Christiano et al, 2005). The results also provide evidence in support of the theoretical framework that nominal rigidity stems from output through different production processes. These results also allude that the monetary policy shock is exogenous and not affected by a systematic response to inflationary pressures such as oil price shocks¹⁸

A positive interest rate shock gradually leads to a fall in inflation. In Botswana, Ghana and Kenya, the decline in inflation takes on average 5 to 7 quarters following the contemporaneous period to the shock to monetary policy. Results in Algeria, South Africa and Tunisia indicate that inflation persists for at least 12 quarters after the shock. The response of inflation to a monetary policy shock in Nigeria is mild. In Uganda, prices are less sticky as inflation declines immediately below zero after the shock to monetary policy. These results show that monetary policy affects relative prices which are consistent with the theoretical framework and with evidence from the sign restriction literature. Rafiq and Mallick (2008)

¹⁷Lucchetti (2006) argues fervently that restrictive probability bands is mostly used in the SVAR literature to attest the true significance of the impulse responses. In addition, IRF's derived via probability bands, gives a more representative analysis of the response of shocks (Doan, 2010).

¹⁸Kim and Roubini (2000) found similar evidence for the U.S monetary policy.

found that following a rise in interest rate, inflation declines and prices are sticky; with a delayed impact of at least 6 quarters after the shock to monetary policy.

Also evidence from the literature suggests that when monetary policy shocks are identified with innovations in the interest rate, a positive interest rate shock induces an initial fall in monetary aggregates. This is evident in the case of Ghana where the money supply falls below zero, while the response is mild in South Africa and Uganda. In Kenya a positive interest rate shock affects the money supply variable for 11 quarters following the shock to monetary policy. In Nigeria and Tunisia, the money supply falls rapidly below zero in response to a rise in interest rate. These results concur with the theoretical framework of the identifying restriction; that in the absence of a liquidity puzzle, a positive increase in the interest rate leads to a fall in the money supply.

In Algeria, commodity prices decline immediately after a positive shock to monetary policy. In Botswana, commodity prices fall initially but start to rise in the short-to-medium term and reaches its peak after 6 quarters, while inflation declines back to lower levels. This suggests that part of the increase in inflation in Botswana is due to commodity price shocks brought about by expectations of future increases in the short-term interest rate. This may also be due to the inflation-pass through effects from South Africa, which is a major trading partner with Botswana.

In response to a positive monetary policy shock, the short-term interest rate increase in all countries. However, the monetary policy shock in Kenya and Nigeria is manifested by a gradual lowering of the interest rate (interest rate inertia). We argue that this may reflect a change in the monetary policy framework from monetary targeting to inflation targeting which was initiated by the CBK in 2008. In Nigeria, this corresponds with the post liberalization periods which were characterized by the introduction of SAP and changes to macroeconomic reforms. Berument et al (2013), Mountford (2005) and Uhlig (2005) found results were consistent for the major industrialized European countries and the U.S, based on the sign restriction approach that the interest rate rises in response to a positive monetary policy shock.

Lastly, a contractionary monetary policy that increases the domestic interest rate lead to a depreciation of the nominal exchange rate in Algeria, Botswana, Ghana, Kenya, Nigeria and Uganda. The impact of an exchange rate puzzle is explained by the fact that the domestic currency become uncompetitive in the

foreign exchange market, due to lower interest rate relative to the world interest rate, as it can be explained by the theory of the uncovered interest rate parity. This leads to higher net exports as it makes imports more expensive than exports. Although the positive exchange rate shocks (depreciation of the exchange rate) may have had short run stimulus on the economy through exports, but the higher import prices are inflationary. Exchange rate depreciation may be responsible for the rise in inflation after a rise in interest rate. This shows weak exchange rate channel of the monetary policy transmission mechanism in the African economies.

In South Africa, a positive innovation in the short-term interest rate leads to a gradual appreciation of the exchange rate. The case of South Africa suggests that in the medium to long-term the exchange rate returns to zero which is consistent with the Dornbusch (1976) overshooting model. In response to a positive interest rate shock, the exchange rate appreciates with a delayed overshooting in Tunisia. This is manifested by the fact that the exchange rate appreciates over the period contemporaneous to the shock to monetary policy. This may have resulted from the fact that the exchange rate policy in Tunisia is based on the crawling peg, where the Tunisian Dinar is fixed to a basket of currencies, but it's subject to frequent adjustment in order to maintaining the stability of the domestic currency. Eichenbaum and Evans (1995) and Bjornland (2008) have also documented evidence in support of an exchange rate appreciation after a rise in interest rate.

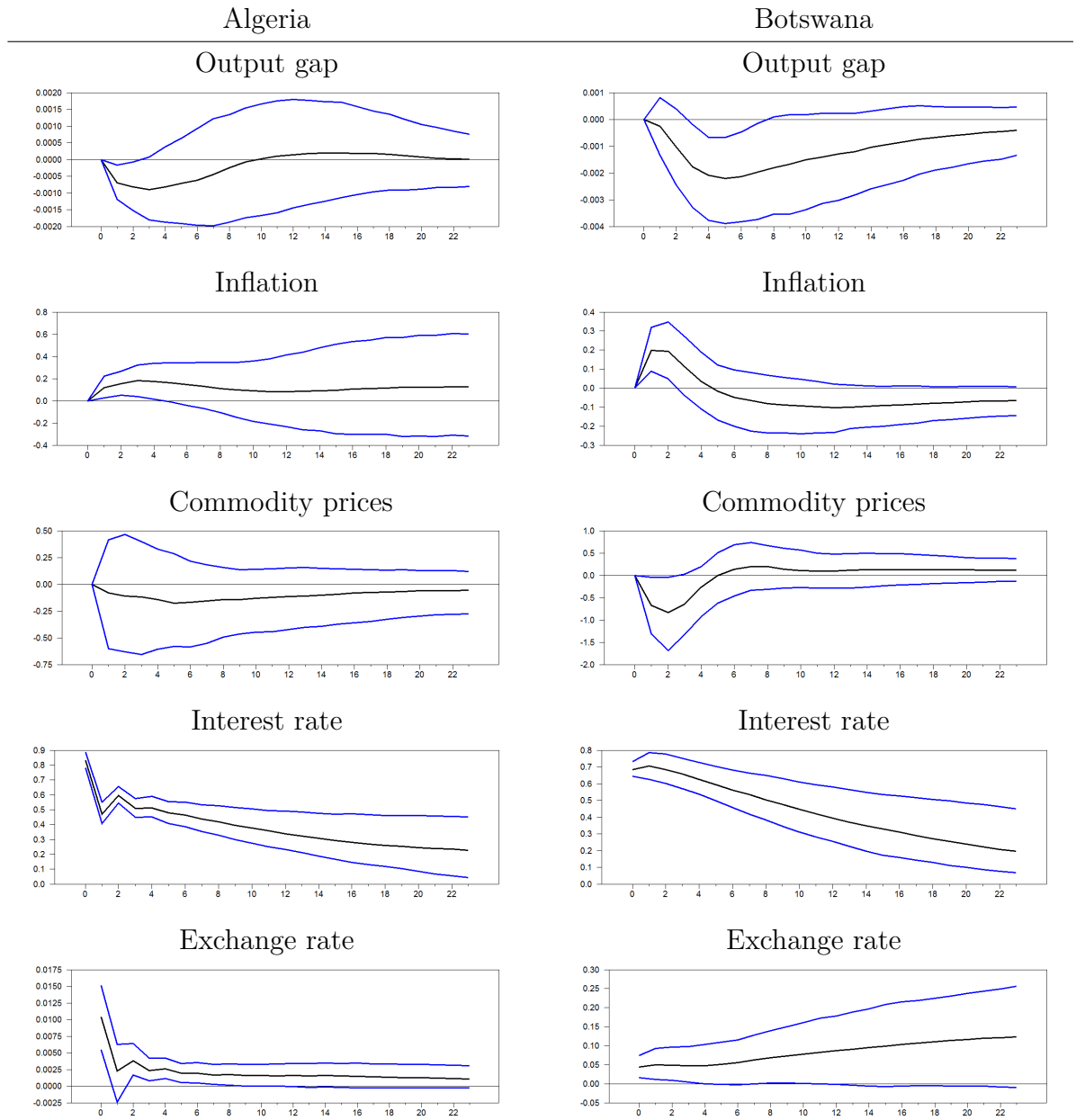


Figure 5.1: Impulse Responses for Algeria and Botswana to Structural one SD Monetary Policy Shocks.

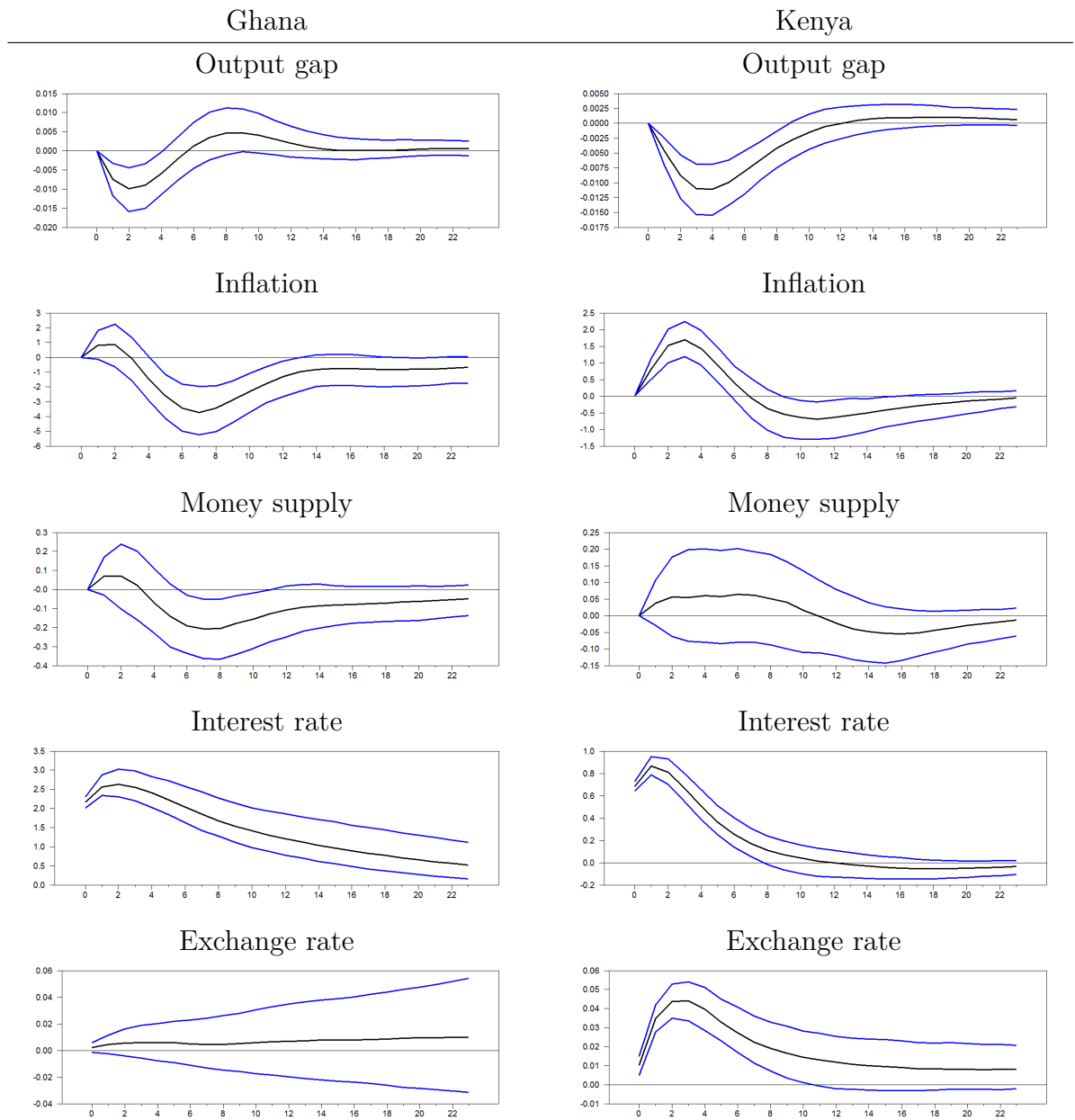


Figure 5.2: Impulse Responses for Ghana and Kenya to Structural one SD Monetary Policy Shocks.

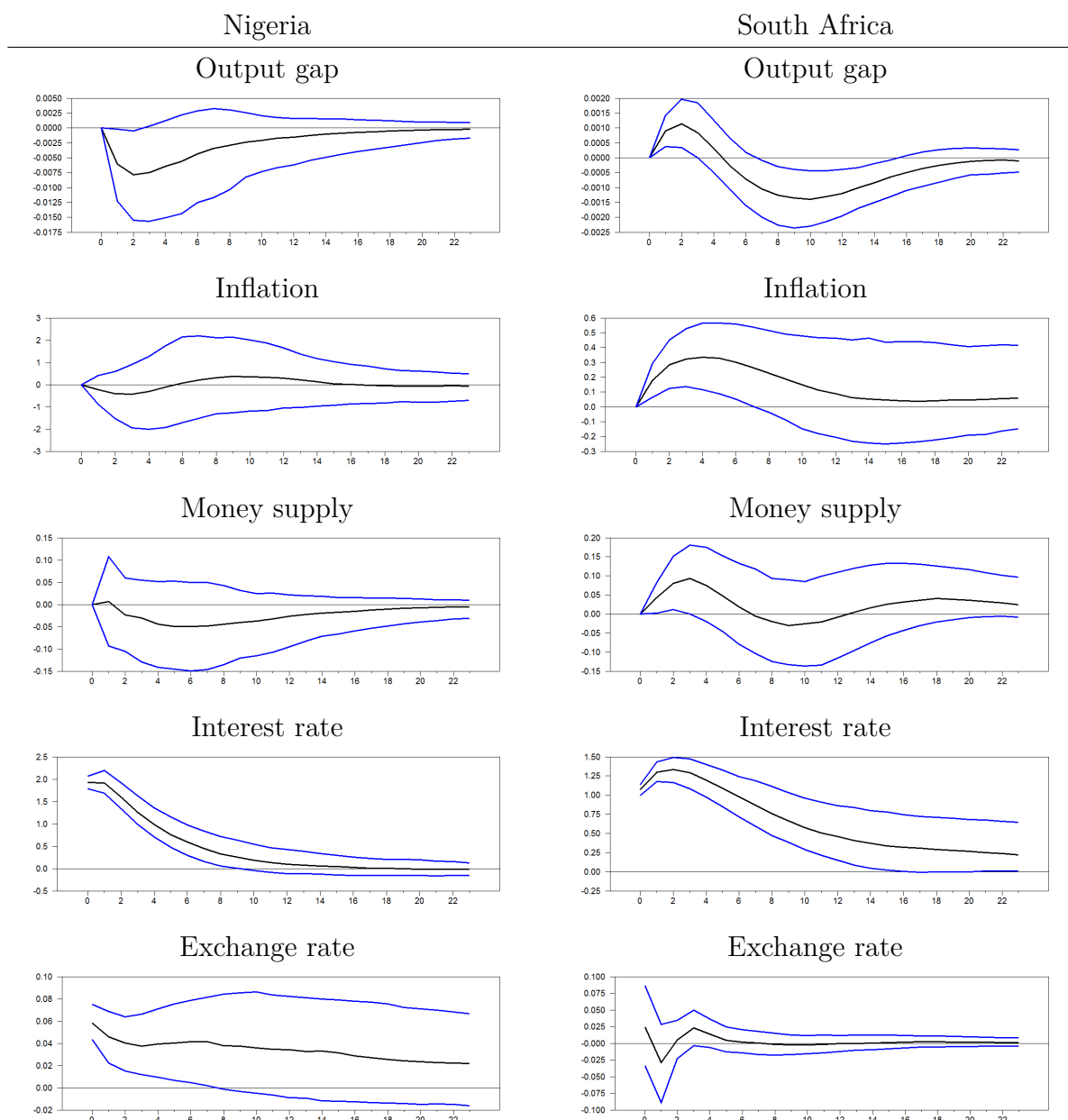


Figure 5.3: Nigeria and South Africa Impulse Responses to Structural one SD Monetary Policy Shocks.

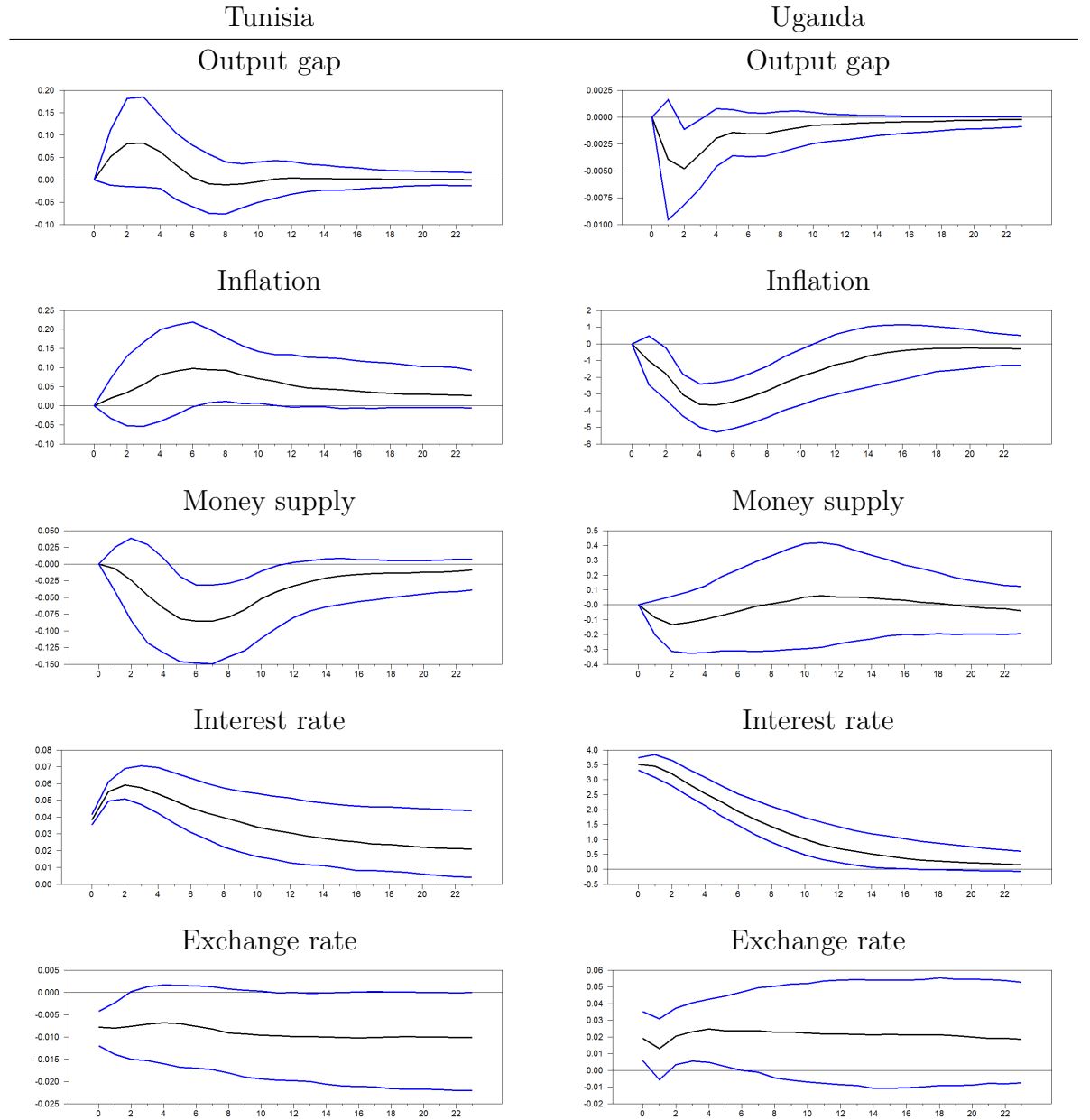


Figure 5.4: Tunisia and Uganda Impulse Responses to Structural one SD Monetary Policy Shocks.

5.8 Variance Decomposition Results

5.8.1 Introduction

The IRF measure the sign and magnitude of a given shock, but their relative contribution is better assessed by the FEVD. Results for the FEVD are presented in Tables 5.3 to 5.10 for the output gap and inflation, which are the non-policy variables for the African economies over 24 quarters after the shock to monetary policy. A shock to the output gap will affect the output gap, but it will also be

transmitted to all of the variables in the system through the dynamic effect of the SVAR. To determine the overall contribution of the monetary policy shocks on the non-policy variables, we assess the variance of the output gap, inflation, commodity prices, the money supply and the exchange rate that are due to monetary policy and the exchange rate. This provides evidence of the effectiveness of monetary policy instruments which are analysed in section 5.8.2 and section 5.8.3. The aim is to determine whether interest rate or the exchange rate are the dominant sources of fluctuations to output gap and inflation in the African economies?

5.8.2 Contribution of the output gap

The variance decomposition of the output gap indicates that between 65 to 100% of the variation in the output gap is explained by its own shock. This indicates that aggregate supply shocks are the most dominant factors affecting the output gap fluctuations in the sample economies. Ahmad and Pentecost (2012) found that aggregate supply shocks are the most predominant determinants of asymmetric relationships in output gap in the African economies, accounting for more than 70% of its variance. Hartley and Whitt (2003) also reported similar evidence for the European area by stressing that supply shocks account for much of the variance in inflation and output for Germany, France, the UK and U.S.

The impact of demand shocks on the output gap differs from country-to-country. This accounts for less than 1% of the variance in the output gap in Nigeria and Uganda and between 1-12% in Algeria, Botswana, Ghana, Kenya and South Africa after the twenty-fourth quarter horizon. The results reveal that the impact of demand shocks are largest in Tunisia, accounting for 29% of the variance in the output gap but least for Nigeria. The relative price (commodity price shocks) produce 3-8% of the variance in the output gap in Botswana but less than 2% in Algeria. This emphasizes the impact of Botswana's diamonds on the output gap. The relative contribution of the money supply shock to the output gap varies across countries. It ranges from between 1-4% in Ghana, Tunisia and Uganda and to between 8-12% in Kenya and Nigeria. Reports also indicate that the money supply shocks are the dominant initiator of fluctuations to the output gap in Nigeria and South Africa accounting for 12-28% after eight quarters. This is partly explained by the relatively large size of these economies and functionally well developed financial markets.

The relative contribution of fluctuations in the output gap due to the mon-

etary policy shocks is moderate. This accounts for less than 1% of the variance in Algeria and Tunisia. The relative contribution is between 1-6% in Botswana, Ghana, Nigeria and South Africa and Uganda. Monetary policy has the strongest impact on the output gap in Kenya. This accounts for 8-17% of the variance in the output gap. This is partly explained by the series of negative supply shocks (such as drought in the mid 1990's) which affected monetary policy actions in order to stabilize the economy. The fluctuation in the output gap explained by the exchange rate is mild across countries. This accounts for less than 1% in all countries in the sample with the exception of Nigeria and Tunisia where the exchange rate shocks accounts for approximately 1-2% of the variation in the output gap. This is because the exchange rate arrangements in Nigeria and Tunisia are based on a managed float and crawling peg exchange rate arrangements respectively.

A key finding of our results is that monetary policy shocks on average explain a higher proportion of the variance in the output gap than the exchange rate. This shows a shift in monetary policy focus away from exchange rate management to interest rate targeting. The contributions and the conclusions drawn from these analyses are three fold. Firstly, own shocks to the output gap explain a higher proportion of its variance than the other shocks in the system. Secondly, with the exception of Kenya, monetary policy shocks are not the dominant produce of output gap fluctuations in the sample economies. Thirdly, the relative contributions of innovations in inflation, money supply, the interest rate and commodity prices to the output gap are moderate.

5.8.3 Contribution of Inflation

The variance decomposition of inflation indicates that between 29-99% of the shocks to inflation are accounted for by its own innovations. The influence of demand shocks on inflation is less persistent in Kenya and fell gradually from 31-39% after the eighth quarter. In Algeria, Ghana and Uganda, the impact of demand shocks on inflation is mild after eight quarters contemporaneous to the shock in inflation. We found that in countries with a relatively large GDP (such as Botswana, Nigeria, Tunisia and South Africa), the influence of demand shocks on inflation are stronger. The case of Botswana may be attributed to trade links with South Africa, putting upward pressure on the price level or through changes in the exchange rate. Chowdhury (2006) argues that the cost channel mechanism may propagate movements in the exchange rate, which indirectly affects inflation.

Innovations in the output gap contributed between 1-43% of the variation in

inflation while the interest rate and the exchange rate contributed between 1-11% and 1-9% respectively after a 24th quarter horizon. There is evidence that commodity price shocks account for much of the variations in inflation in Botswana (approximately 14%) while this is less than 9% in Algeria. Buckle et al (2007) found similar evidence in the case of New Zealand and emphasised that commodity prices affects inflation in small open economies. Innovations in the money supply contributed between 1-45% of the variation in inflation. This is highest in Uganda, partly explained by the de jure monetary targeting framework and the introduction of ITL by the BoU in 2011. Saxegaard (2006) found similar evidence in the case of Uganda arguing that excess liquidity created inflationary pressures on the economy.

To summarise the importance of the other shocks to inflation, our results indicate that the relative contribution to inflation in Algeria, Ghana, Kenya and Tunisia are aggregate supply shocks. Innovations in the money supply account for the relative significance of inflation in Nigeria, South Africa and Uganda, while commodity price shocks partly explained shocks to inflation in Botswana.

5.8.4 Correlations of Contemporaneous Shocks

We also tested for the cross correlations of the contemporaneous aggregate demand and supply shocks, following the approach developed by Buigut and Valev (2006). The aim was to determine whether the asymmetry in the monetary policy arises from domestic shocks (as evidenced from the variance decompositions) or whether they came from the partial correlations of the contemporaneous aggregate demand and aggregate supply shocks for the sample of the African economies. These results are presented in Table 5.11 for the African economies for the output gap and inflation. There exit a few significant positive correlations, but one cannot identify any form of consistency regarding the inflation pass-through between countries. These results reinforce the finding that own shocks from the domestic economy are more persistent than those emanating from the other African economies through cross-correlations, in terms of the output gap and inflation.

Table 5.3: Algeria: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	pc_t	i_t	er_t	H/steps	y_t	π_t	pc_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	43.47	56.52	0.00	0.00	0.00
4	95.47	3.48	0.64	0.34	0.05	4	38.54	57.50	0.93	0.64	2.37
8	92.89	5.17	1.51	0.31	0.10	8	22.14	70.19	0.73	0.71	6.21
12	92.73	5.13	1.71	0.29	0.11	12	28.18	64.53	0.54	0.46	6.26
16	90.55	7.27	1.66	0.30	0.21	16	36.56	56.62	0.66	0.35	5.79
20	87.73	9.95	1.60	0.28	0.42	20	40.43	52.75	0.76	0.36	5.68
24	86.27	11.27	1.58	0.27	0.58	24	41.63	51.37	0.80	0.43	5.74

Note: H-steps is the ahead forecast error variance over 24 quarters.

Results are obtained using the RATS software.

Table 5.4: Botswana: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	pc_t	i_t	er_t	H/steps	y_t	π_t	pc_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	1.74	98.25	0.00	0.00	0.00
4	93.41	2.09	3.93	0.56	0.00	4	3.36	83.44	11.65	1.47	0.06
8	81.85	9.00	7.00	2.11	0.02	8	6.70	79.71	12.89	1.44	0.24
12	78.29	10.59	8.09	2.82	0.02	12	6.93	76.63	13.78	1.86	0.79
16	77.75	10.61	8.00	3.54	0.07	16	6.90	75.78	13.67	2.39	1.24
20	77.54	10.55	7.98	3.76	0.14	20	6.98	75.06	13.56	2.77	1.61
24	77.38	10.51	7.99	3.86	0.23	24	7.06	74.48	13.45	3.05	1.93

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.5: Ghana: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	31.63	68.36	0.00	0.00	0.00
4	90.09	6.97	0.21	2.63	0.07	4	28.03	71.05	0.49	0.30	0.11
8	83.99	9.82	3.16	2.90	0.11	8	33.61	53.94	5.11	5.61	1.71
12	82.67	9.81	3.70	3.61	0.19	12	32.60	49.46	5.15	9.11	3.65
16	82.49	9.83	3.79	3.66	0.20	16	32.54	48.31	5.06	9.36	4.71
20	82.46	9.85	3.80	3.67	0.20	20	31.99	47.51	5.23	9.59	5.67
24	82.42	9.84	3.82	3.70	0.20	24	31.45	46.72	5.32	9.78	6.69

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.6: Kenya: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	37.83	62.16	0.00	0.00	0.00
4	90.56	0.53	0.21	8.55	0.12	4	25.69	58.77	1.57	13.19	0.75
8	78.82	1.48	2.27	17.26	0.16	8	36.56	39.87	11.84	11.25	0.47
12	73.02	2.35	8.27	16.20	0.14	12	41.24	32.80	15.21	10.34	0.39
16	71.39	2.87	10.14	15.44	0.14	16	41.34	31.95	14.95	11.33	0.42
20	71.20	3.01	10.20	15.43	0.14	20	40.91	31.60	15.38	11.63	0.45
24	71.09	3.01	10.20	15.53	0.15	24	40.71	31.43	15.73	11.62	0.49

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.7: Nigeria: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	2.96	97.03	0.00	0.00	0.00
4	89.30	0.04	7.06	1.96	1.32	4	1.11	95.93	2.71	0.21	0.02
8	83.92	0.08	11.33	3.20	1.46	8	2.25	94.40	2.93	0.20	0.20
12	83.42	0.33	11.26	3.52	1.47	12	2.60	93.32	3.17	0.38	0.50
16	83.27	0.41	11.24	3.59	1.48	16	2.67	92.76	3.21	0.44	0.90
20	83.25	0.41	11.24	3.61	1.48	20	2.77	92.29	3.19	0.45	1.29
24	83.24	0.41	11.23	3.61	1.49	24	2.81	91.93	3.18	0.46	1.62

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.8: South Africa: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	1.20	98.79	0.00	0.00	0.00
4	94.02	0.28	3.97	1.71	0.00	4	2.74	89.24	0.26	2.38	5.35
8	74.95	0.46	22.47	2.02	0.08	8	3.81	80.65	6.00	3.55	5.97
12	70.76	0.99	23.62	4.40	0.21	12	3.09	74.86	12.95	3.36	5.72
16	68.35	1.24	24.63	5.52	0.24	16	3.24	72.96	14.99	3.15	5.63
20	65.96	1.30	26.92	5.55	0.24	20	3.33	72.91	14.97	3.09	5.67
24	65.67	1.36	27.19	5.52	0.24	24	3.29	73.06	14.81	3.11	5.71

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.9: Tunisia: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	0.86	99.133	0.00	0.00	0.00
4	70.55	27.33	0.14	0.89	1.08	4	9.06	90.41	0.08	0.31	0.13
8	67.18	28.42	2.09	0.98	1.32	8	23.72	73.83	0.54	1.74	0.16
12	66.42	29.06	2.24	1.96	1.30	12	23.24	73.38	0.56	2.63	0.19
16	66.29	29.11	2.30	1.96	1.33	16	23.88	72.48	0.54	2.90	0.19
20	66.25	29.12	2.32	1.95	1.34	20	24.07	72.09	0.55	3.06	0.21
24	66.24	29.12	2.32	0.95	1.35	24	24.14	71.90	0.55	3.15	0.24

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.10: Uganda: Variance Decomposition

Contribution of the Output gap due to;						Contribution of Inflation due to;					
H/steps	y_t	π_t	m_t	i_t	er_t	H/steps	y_t	π_t	m_t	i_t	er_t
1	100.00	0.00	0.00	0.00	0.00	1	25.70	74.29	0.00	0.00	0.00
4	98.35	0.42	0.26	0.90	0.05	4	20.42	59.41	6.58	2.41	11.18
8	97.99	0.52	0.36	1.06	0.06	8	12.29	35.18	38.94	6.92	6.66
12	97.71	0.56	0.55	1.12	0.06	12	10.12	29.87	46.65	7.47	5.87
16	97.54	0.57	0.69	1.13	0.06	16	9.83	29.73	46.29	7.41	6.73
20	97.46	0.56	0.79	1.14	0.06	20	9.75	29.81	45.23	7.25	7.94
24	97.43	0.57	0.78	1.45	0.07	24	9.68	29.64	44.69	7.09	8.88

Note: H-steps is the ahead forecast error variance over 24 quarters.

Table 5.11: Correlations of Contemporaneous Aggregate Supply and Demand Shocks

Table 5.11a: Cross Correlations of Aggregate Supply Shocks

	$y_t - alg$	$y_t - bots$	$y_t - gha$	$y_t - ken$	$y_t - nig$	$y_t - sa$	$y_t - tuns$	$y_t - uga$
$y_t - alg$	1.000							
$y_t - bots$	-0.013	1.000						
$y_t - gha$	-0.058	0.263	1.000					
$y_t - ken$	0.189	0.074	0.104	1.000				
$y_t - nig$	0.110	0.158	0.213	0.213	1.000			
$y_t - sa$	0.221	0.072	-0.099	-0.037	0.029	1.000		
$y_t - tuns$	0.107	-0.452	-0.076	0.256	-0.228	-0.020	1.000	
$y_t - uga$	-0.061	-0.007	0.149	0.107	-0.116	-0.274	0.094	1.000

Table 5.11b: Cross Correlations of Aggregate Demand Shocks

	$\pi_t - alg$	$\pi_t - bots$	$\pi_t - gha$	$\pi_t - ken$	$\pi_t - nig$	$\pi_t - sa$	$\pi_t - tuns$	$\pi_t - uga$
$\pi_t - alg$	1.000							
$\pi_t - bots$	-0.102	1.000						
$\pi_t - gha$	-0.268	-0.095	1.000					
$\pi_t - ken$	0.109	0.313	-0.252	1.000				
$\pi_t - nig$	0.046	0.049	0.077	0.049	1.000			
$\pi_t - sa$	0.074	0.036	0.029	0.109	0.218	1.000		
$\pi_t - tuns$	0.152	-0.002	-0.260	0.171	-0.268	-0.058	1.000	
$\pi_t - uga$	0.303	0.031	-0.123	0.112	-0.099	-0.036	0.112	1.000

Note: Estimation by the EvIEWS software.

5.9 Robustness of the Estimation Method

We consider a departure from the baseline model in order to test for the robustness of our results. The empirical model assumes that the exchange rate reacts contemporaneously to all other shocks and the variables are ordered as follows: $z_t = [y_t, \pi_t, m_t, i_t, er_t]'$ and $z_t = [y_t, \pi_t, pc_t, i_t, er_t]'$, in the case of Algeria and Botswana. Following Christiano et al (2005), we consider ordering the short-term interest rate last such that monetary policy reacts contemporaneously to shocks from all other variables. This gives the following alternative ordering of the variables in the identified VAR model; $z_t = [y_t, \pi_t, m_t, er_t, i_t]'$ and $z_t = [y_t, \pi_t, pc_t, er_t, i_t]'$ respectively. The intuition is that macroeconomic variables are unaffected contemporaneously by shocks to monetary policy.

Figure 5.5 presents some key results of the impulse responses, which are derived through Monte Carlo simulations with 500 draws and 0.16 and 0.84 percentile bands for a selection of the African economies. The IRF give similar qualitative results to those of the baseline model. One possible explanation is that the SVARs are not sensitive to ordering but rather based on the identifying restrictions. According to Enders (2010), ordering of the variables is insensitive, if the correlation between the variables is low and the VAR model satisfies stability conditions. This has been discussed under section 5.3 in this Chapter. There is evidence to suggest that the transmission mechanism of the monetary policy shocks is not affected by the ordering of variables but is dependent on the theoretical framework underlying the structures of the African economies.

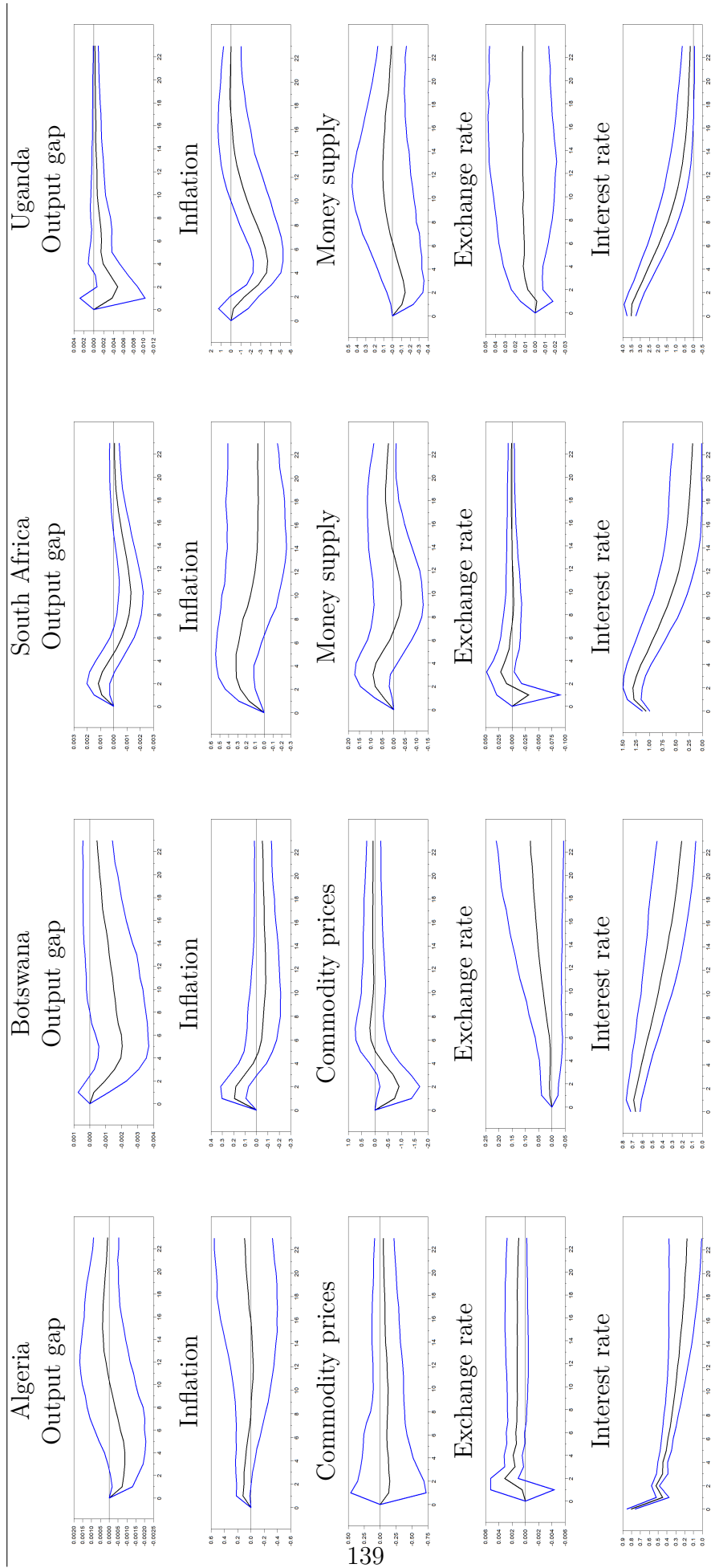


Figure 5.5: Impulse Responses to Structural one SD Shock in the Interest Rate

5.10 Conclusions and Policy Implications

This chapter contributes to the understanding of monetary policy effectiveness of the African economies, using the SVAR approach and data for the period 1980:01 to 2012:04. Monetary policy is estimated by assuming that shocks are the dynamic effects of the aggregate supply, the aggregate demand, the money demand, commodity price shock, the money supply shock and the exchange rate shock. The main conclusions and policy implications of our results are as follows: the response of the output gap fall is unanimous across countries in response to a positive shock to the short-term interest rate. Findings from the IRF suggest that monetary policy has a significant effect on the output gap in the short-term, while in the long-run, the output gap returns to its original levels for the period contemporaneous to the shock. We also established that monetary policy affects relative prices. A fall in inflation is explained by the fact that the positive interest rate shock is likely to be small and not very persistent. This is because in the medium-to-long run, the interest rate will fall, seen by the gradual return of the output gap to its long-run equilibrium levels.

In terms of the variance decompositions, the results suggest that when monetary policy shocks are identified through changes in the money supply, the impact on the output gap is stronger than that identified through changes in the exchange rate and the short-term nominal interest rate. These results are consistent with the study of Osorio and Unsal (2013) who found similar evidence for a sample of Asian and Emerging market economies. It appears that monetary policy shocks are not the dominant sources of the output gap fluctuations but shocks to aggregate supply. This is consistent with evidence from the literature that supply shocks are the most dominate forces affecting the output gap and inflation (Ahmad et al, 2012). On average, monetary policy shocks explain a more significant proportion of the variance in the output gap than the exchange rate. This shows a shift in monetary policy focus away from exchange rate management to interest rate targeting as the African economies have become more market oriented.

5.11 Appendix

5.11.1 A Structural VAR - Dummy Variable Identification Scheme

As was mentioned in Chapter 4, the problem of structural breaks is resolved by adding dummy variables based on the LS test where the breaks occurred. This also included the period when inflation targeting frameworks were introduced, in order to test whether the changes in the economy had major effects on monetary policy. The use of policy dummies is to account for the changes in macroeconomic policies such as SAP and stabilization programmes. The response function take the value of one for the period of the structural breaks and zero otherwise. This approach is closely related to the study of Kim (2001) who considered adding dummy variables to model the changes in the U.S monetary policy.

We extended the model in equation (5.6) by adding the dummy variables in order to resolve the problem of structural breaks in the African monetary policy. The empirical model imposes over-identified restriction on the system. The assumption is that the exchange rate and the interest rate react contemporaneously to the dummy variable. The model with the dummy variable is over-identified by two restrictions.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} & 0 & 0 \\ 0 & 0 & \beta_{43} & 1 & \beta_{45} & 0 \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 1 & \beta_{56} \\ 0 & 0 & 0 & \beta_{64} & \beta_{65} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^\pi \\ \varepsilon_t^m \\ \varepsilon_t^i \\ \varepsilon_t^{er} \\ \varepsilon_t^{dum} \end{bmatrix} = \begin{bmatrix} v_t^{as} \\ v_t^{ad} \\ v_t^{md} \\ v_t^{ms} \\ v_t^{bop} \\ v_t^{tb} \end{bmatrix} \quad (5.16)$$

The test for the over-identifying restrictions follows the log-likelihood ratio test statistic (Enders, 2010). This is to test whether the identifying restrictions are valid with respect to the data. These results are presented in Table 5.12. The model passes the test for the over-identifying restrictions, which follows the chi-squared distribution with two degrees of freedom. So over-identifying restriction holds and the null hypothesis is not rejected. The IRF's to an interest rate shock are unchanged to the baseline identification scheme. The response of the dummy variable is negligible following the variance decomposition of shocks as it explains less than 1% of the variance in the output gap and inflation for the sample of the African economies. This may be due to the fact that the structural break dates are stationary within a unit root and therefore the dummy variables are

not significant. The next chapter examines whether monetary policy responded asymmetrically to shocks to inflation, but the dummy variable results are not reported due to the insignificance of the dummy variables. It suggest of changes in monetary policy has been gradual and not producing a break.

Table 5.12: Likelihood Test of Over-identifying Restrictions

	Chi-squared	Significance levels
Algeria	$\chi^2(2) = 1.04$	0.59**
Botswana	$\chi^2(2) = 1.32$	0.52**
Ghana	$\chi^2(2) = 0.49$	0.78**
Kenya	$\chi^2(2) = 1.96$	0.38**
Nigeria	$\chi^2(2) = 4.60$	0.09**
South Africa	$\chi^2(2) = 1.24$	0.54**
Tunisia	$\chi^2(2) = 2.55$	0.28**
Uganda	$\chi^2(2) = 1.05$	0.59**

Note: $PV > 5\%$ for the model to be significant

** means the null of over-identification cannot be rejected

Results are obtained using the RATS software.

Chapter 6

The Asymmetric Effects of Monetary Policy in a Sample of African Countries

6.1 Introduction

In recent years, the role of monetary policy has gained increased attention among policy makers in terms of stabilising the economy. This is usually characterized by changes in economic policies and macroeconomic reforms. Inflation is often used as a signal to determine the credibility of monetary policy as well as the behaviour of economic agents. If inflation exceeds a threshold level, this may indicate inefficiency on the part of the central bank and failure to stabilise the economy (Zhang, 2011). If the inflation is too low, this could also mean inefficiency on the part of the monetary authorities to stimulate aggregate demand. On the contrary, maintaining inflation within a monetary policy target, is often regarded as policy effectiveness and therefore gives credibility on the part of the central bank. One challenge is to find out how low or high inflation has to be in order to induce an efficient or credible monetary policy framework, especially in developing countries where inflation has been rising.

This chapter examines the asymmetric effects of monetary policy with respect to the inflation threshold level for the sample of African economies using the TVAR approach and data from 1980:01 to 2012:04. Inflation regimes are determined endogenously in the economy, rather than splitting the data into subsamples.¹ The objective of this study is to determine the optimal inflation rate for

¹See Hansen (2000), Catik and Martin (2012). One limitation with this approach is the fact that it normalizes a break point in the data and hence loss of degrees of freedom. And secondly, periods of low and high inflation may be as well, far beyond the established break dates.

the selected countries. This is potentially important, as achieving a single-digit inflation target remains the main objective of monetary policy in the countries in question. We aim here to capture the asymmetric propagation of monetary policy shocks through the inflation threshold, and to make the following contributions. Firstly, we employ a non-parametric test to determine if there is evidence of asymmetry in the inflation rate and what implications it has on monetary policy? Secondly, we consider a multivariate TVAR model by looking at the monetary policy transmission mechanism rather than a univariate model only.

The TAR model provides the best method for determining the inflation threshold effects. First introduced by Tong (1983) in a univariate model, it has been extended to systems of equations such as threshold cointegration and TVAR models as part of an increasingly rich literature on non-linear empirical models. A distinguishing feature of the TVAR approach is that it allows for the possibility of regime switches to be determined endogenously in the system. This implies that shocks to any of the variables may, through their impact on inflation, induce a shift to different regimes (Balke, 2000). Mojon (2008) examined U.S monetary policy between 1960 - 2005 and find that shifts in the mean of inflation were triggered by the domestic economy, brought about by changes in monetary aggregates. According to Hansen (1999b), TVAR models are often used in the literature because of their simplicity in terms of specification, estimation and interpretation of the results. The theoretical framework used in this chapter has been taken from Chapter 2 of the literature review which covers the TAR framework.

The rest of the chapter is organized as follows. Following the introduction, section 6.2 presents the motivation and empirical contributions of the study. Section 6.3 discusses the choice of the threshold variable propagating non-linearity in monetary policy and regime switching. This is followed by the methodology in section 6.4 involving; a non-parametric method when the general form of non-linearity of inflation is unknown. Section 6.5 introduces the model and testing and estimation of the TVAR model in section 6.6. Section 6.7 describes the data. The empirical results are analysed in section 6.8 for two types of inflation threshold models. This consists of univariate inflation threshold estimation and a multivariate TVAR framework. Section 6.9 explains the impulse responses to a one SD shock from monetary policy, which is identified as an interest rate shock. Lastly, section 6.10 is a concise analysis of the conclusions and policy implications of the results.

6.2 Motivation of the Study in African economies

The bulk of the literature has centered on exchange rate misalignment (with the assumption that asymmetry in the exchange rate arises from transaction costs), financial market frictions and measuring changes in the business cycle, with limited research having been done on inflation, which is a potential area of contribution of this chapter. These models assume that markets are functionally developed and influenced by broad macroeconomic aggregates. By implication, non-linearity stems from imperfections in credit conditions and the GDP as was discussed in the literature review. However, in the context of the African economies asymmetry in monetary policy, historically emanated from inflation which was then propagated to other sectors of the economy. Figure 6.1 below shows the evolution of inflation for South Africa, Kenya and Algeria in order to depict inflationary trends.

Fig: Evolution of Inflation in South Africa, Kenya and Algeria

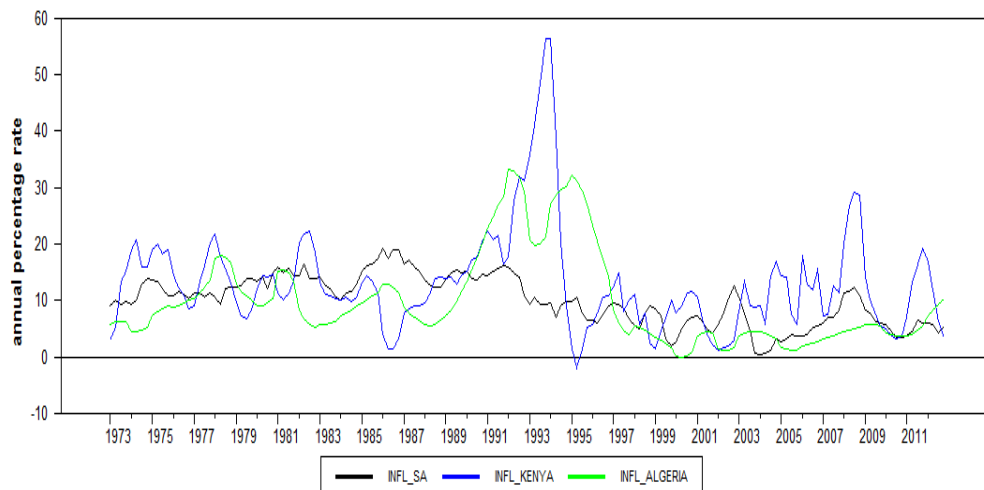


Figure 6.1: Trends in Inflation for a sample of African economies

High inflation has emerged in the African economies since the collapse of the Bretton-Woods fixed exchange rate mechanism causing asymmetric adjustments in macroeconomic framework. The present monetary policy framework is tailored towards reducing inflation to target levels and improving output growth among other macroeconomic measures such as the stability of the exchange rate. It is evident from the present literature that limited research has been conducted on inflation thresholds, but more importantly, on its dynamic interaction with monetary policy. The hypothesis we seek to investigate is what are the implications of inflation threshold means for monetary policy for a sample of African economies. This is because the way monetary policy has been conducted in the African

economies could have created asymmetry in the transmission mechanism regarding monetary policy shocks. This chapter contributes to the literature by using a model that considers the impact of policy changes in the African economies.

The chapter fills an important gap in the literature by estimating two variants of inflation threshold models. These include a univariate and a multivariate threshold model allowing for the dynamic interaction between inflation and monetary policy variables. The aim is to determine the threshold non-linearity between inflation and monetary policy due to large scale stabilization policies and macroeconomic reforms enacted in the eighties and the early-to-mid nineties. In particular, the behaviour of monetary policy and hence monetary transitions may have changed during these periods. This area of research has not been applied much to the African economies where pre and post liberalization policies, are assumed to have affected macroeconomic frameworks.

6.3 Choice of the Threshold Variable

As was mentioned in the literature review, the choice of the threshold variable is often dependent on the rationale of the study. It is necessary to address the caveat raised by Tsay (1989), that the threshold variable should be identified without any adhoc formulation. There is less theoretical evidence regarding the choice of the threshold variable. Following Mojon (2008), Catik and Martin (2012) and Mandler (2012), inflation is used as the threshold variable and is endogenous in the system, causing a switch in regime. This is consistent with the policy background chapter of the African economies where historically, inflation has been the major concern of monetary policy. Friedman (1968) and Mandler (2012) argued that the inflation rates acted as a propagator of shocks to monetary variables.

This section offers two theoretical arguments to underpin the reason why inflation is used as a propagator of the asymmetric adjustment to monetary policy. According to Orphanides and Wilcox (2002), does it matter about the types of monetary policy maker? - a conventional or the opportunistic monetary policy makers. Section 6.3.1 provides a narrative and intuitive approach to central bank credibility. There, we assume the two types of monetary policy makers. Section 6.3.2 introduces the Phillips curve. This is to show how non-linearity in inflation may have caused changes in the dynamic relationship between inflation and the monetary policy reaction function.

6.3.1 Central Bank Credibility

Kydland and Prescott (1977) and BG examined the time-inconsistency problem of the optimal monetary policy and argued that discretionary monetary policy is inefficient as this leads to low credibility on the part of the central bank, which is often characterized by uncertainty and changes in monetary policy preferences over time. BG argued is because “monetary policy was more of an art than a science”. Discretionary policy requiring the central bank relying on subjective decisions when conducting monetary policy (Mishkin, 2007b). In contrast, adhering to a monetary policy rule such as the Taylor (1993) rule or money growth rule, advocated by Friedman (1968) has the advantage of ensuring reputation, commitment and optimal monetary policy. This enables the central bank to form expectations about inflation. To take this discussion further, we distinguish between two types of policy makers, based on Orphanides and Wilcox (2002). These include a conventional and an opportunistic monetary policy maker.

Both types of monetary policy maker take inflation as their main monetary policy objective, but differ slightly in their reaction to inflation. The conventional monetary policy maker reacts gradually and not very persistently when inflation is too high and the optimal monetary policy involves inflation targeting. By being risk averse, the policy maker minimizes the cost of any deliberate monetary policy action by observing inflationary expectations. This explains why monetary policy responds with a lag to inflation (Mandler, 2012).

On the other hand, the opportunistic monetary policy maker’s optimal monetary policy is disinflation, but also considers output stabilization when inflation is low (Orphanides and Wilcox, 2002). Under the opportunistic approach, the central bank undertakes deliberate monetary policy actions based on the following strategies. Tightening of monetary policy by raising the interest rate when inflation is too high, but implementing an expansionary monetary policy through lowering interest rate, when prices are falling rapidly. The central bank adopts inflation targeting when neither inflation is too high nor too low. This narrative approach suggests that inflation affects the credibility of monetary policy. It’s mechanical approach is examined in the next section, to show how changes in the slope of the Phillips curve affects monetary policy preferences.

6.3.2 Changes in Monetary Policy Reaction Function

In order to summarise the two variants of the monetary policy makers, the Phillips curve is introduced. This is based on the assumption that the monetary policy

reaction function will be non-linear in response to changes in the mean of inflation (Mojon, 2008). The augmented Phillips curve relates current inflation (π_t) to expected inflation (π_t^e), the output gap ($y_t = (y_t - \bar{y})$) and a supply shock (s_t).

$$\pi_t = \pi_t^e + \alpha(y_t) + s_t \quad (6.1)$$

Where, y_t is the output gap and $\alpha > 0$, measures the sensitivity to the output gap. Assuming rational expectations, monetary policy makers observes, s_t and will not make any unsystematic errors as being guided by the optimizing behaviour of economic agents (Woodford, 2003). By implication, the central bank's reaction function is analysed as deviations from the inflation target (π^*) and the output gap. This is based on the following quadratic loss function.

$$Mp \mid l_{fx} = (\pi_t - \pi^*)^2 + \alpha(y_t - \bar{y})^2 + \alpha_1 \mid (y_t - \bar{y}) \quad (6.2)$$

The central bank's loss function includes deviations from the output gap $\{(y_t - \bar{y})^2\}$ and is conditional on the output gap ($y_t - \bar{y}$), with coefficient α_1 . This is to introduce the opportunistic approach to disinflation (Orphanides and Wilcox, 2002). Equation (6.2) suggests that the optimal strategy for the conventional monetary policy maker occurs when $\alpha = 0$ and $\alpha_1 = 0 \iff Mp \mid l_{fx} = (\pi_t - \pi^*)^2$. The first order condition requires that $2(\pi_t - \pi^*) = 0$. If current inflation equals the inflation target: $\pi_t = \pi^*$, it implies that inflation targeting is the optimal strategy for the conventional monetary policy maker.

For the opportunistic policy maker, it is further assumed that the inflation target is expressed as the level of previous inflation: $\pi^* = \beta\pi_{t-1}$. If economic agents expect no inflation from the previous period, $\pi^* = 0$. The difference arises in the way inflationary expectations are formed. In this case, the opportunistic approach is optimal when, $\beta > 0$ and $\alpha_1 > 0$ irrespective of whether $\alpha \geq 0$ (Orphanides and Wilcox, 2002). It can be concluded from the analyses that inflation targeting is the main concern for a conventional monetary policy maker. In contrast, an opportunistic monetary policy maker considers both inflation and the output gap, under the weaker assumption that the central bank has direct control over output.²

²In practice, conventional monetary policy uses interest rate to influence changes in the real economy.

6.4 The Methodology

The starting point is to hypothesize that the form of non-linearity of inflation is unknown. This section discusses the Brock et al (1996) test in order to examine the non-linearity of inflation of an unknown form. This method is plausible when there is no prior knowledge about the existence of non-linearity in inflation.

6.4.1 The BDS Test

The Brock et al (1996) test³ is the most popular general test for non-linearity of an unknown form, originally designed to test the null hypothesis of the error term being Gaussian white noise. The BDS test statistic is based on the correlation integral in equation (6.3). Considering the time-series, y_t , representing the inflation rate for $t = 1, 2, \dots, T$ observations and its m history⁴ as: $y_t^m = (y_t, y_{t-1}, \dots, y_{t-m+1})$. The correlation integral is defined by the following statistic:

$$C_{m,\varphi} = \frac{2}{T_m(T_{m-1})} \sum_{m < p} \sum_{t \leq T} I(y_t^m, y_p^m, \varphi) \quad (6.3)$$

where $\varphi > 0$ is the distance threshold and p is the lag length. The parameter $I(y_t^m, y_p^m, \varphi)$ is an indicator function which is equal to 1 if $|y_{t-j} - y_{p-j}| < \varphi$ in favour of linearity and zero otherwise in the case of the undefined non-linear alternative hypothesis which is described by the following specification.

$$I(.) = \begin{cases} 1 & \text{if } |y_{t-j} - y_{p-j}| \leq \varphi \\ 0 & \text{otherwise} \end{cases} \quad (6.4)$$

The intuition behind equation (6.4) is that any two m -dimensional points are within a distance of φ of each other. This is reflected in the joint probability.

$$\Pr(|y_t - y_p| < \varphi, |y_{t-1} - y_{p-1}| < \varphi \dots |y_{t-m+1} - y_{p-m+1}| < \varphi) \quad (6.5)$$

The BDS null hypothesis (of linear independence) means that the DGP for inflation is independently, identically distributed (*i.i.d*) such that $C_{m,\varphi} \approx [C_{1,\varphi}]^m$. This means $y_t \sim i.i.d(0, \sigma^2)$, with zero mean and a constant variance. The BDS joint probability is equivalent to the limiting case; $C_{1,\varphi}^m = \Pr(|y_t - y_p| < \varphi)^m$.

³The test was originally developed by Brock et al (1987), based on the concept of the correlation integral, which measures the “frequency with which temporal patterns are repeated” in the data.

⁴Brock and Sayers (1988) found that the values of the embedding dimension (m) ranges between 2 to 5. This was found to be $m = 2$ in the empirical analysis for the sampled economies.

Brock et al (1996) defined the BDS statistic as follows:

$$V_{m,\varphi} = \frac{\sqrt{T}(C_{m,\varphi} - C_{1,\varphi}^m)}{\sigma_{m,\varphi}} \quad (6.6)$$

where, $\sigma_{m,\varphi}$ is the SD of $\sqrt{T}(\cdot)$. Under H_0 and for large samples, it is assumed that the BDS two-tailed test statistic converges to the normal distribution such that linearity of the threshold variable is rejected when $|V_{m,\varphi}| > 1.96$ at the 5% level.⁵ The rejection of the null hypothesis implies the presence of a non-linear dependence of the inflation rate of an unknown form.

6.4.2 Non-Linearity Test Results of the General Form

Table 6.1 shows the results of the BDS test statistic with probability values represented in square parentheses for the inflation rate, when the form of non-linearity is unknown. This test examines the null hypothesis of linear independence of the inflation rate, based on the correlation integral. The small sample size ($T < 100$) for Nigeria and Tunisia restricted estimation of the BDS test statistic. The BDS test result for the remaining African economies are consistent with the finding that the inflation rate is non-linearly dependent. This is because the test statistic is more than their respective critical values.

Table 6.1: Univariate Non-Linear (dependence test) for Inflation

Algeria	Botswana	Ghana	Kenya
19.558	23.391	11.278	14.365
[0.000]	[0.000]	[0.000]	[0.000]
Nigeria	South Africa	Tunisia	Uganda
NA	71.016	NA	12.958
	[0.000]		[0.000]
Results are obtained using the RATS software			

The BDS test is not a specific non-linearity test as it does not require a distributional assumption on the data to be tested. The evidence of non-linearity of an unknown form does not directly imply non-linear dependence of the inflation rate. These results are necessary but not a sufficient condition for non-linearity of the inflation rate. In order to address this limitation, we employ the TVAR framework in section 6.5. This is to conduct proper inference about the existence

⁵Comparing this to the 1% level which is 2.58.

of non-linearity of inflation and because most economic time-series models are subject to specific forms of non-linearity rather than unknown forms.

The TVAR looks at a discrete change in the economy and therefore discontinuity of the thresholds. The plausibility of this method rests on the fact that the changes in policy frameworks were discrete and they were imposed for specific time periods such as SAP's institutional policies. The advantage of the TVAR method compared to alternative approaches such as the Markov switching models is that in Markov switching models, the transition regimes are random which is caused by the gradual evolution of parameters. This means inference is based on random probabilities representing the true nature of the economy. Another method is the Smooth Transition Autoregressive (STAR) model which was initially motivated by Terasvirta (1994) which requires the data to be separated based on the regime break. In the empirical procedure, we have considered the endogenous transition between regimes without random probabilities and regime breaks.

6.5 The Model

This section explains whether a linear model is statistically better than a non-linear multivariate threshold model for the inflation rate. This section differs from the previous section where it was assumed that the form of non-linearity of inflation is unknown. We start by considering a 5-dimensional time-series vector, $z_t = [y_t, \pi_t, m_t, i_t, er_t]'$ for $t = 1, \dots, T$ observations containing the output gap (y_t), inflation (π_t), the money supply (m_t), interest rate (i_t) and the exchange rate (er_t). The TVAR model is composed of monetary policy variables for the period 1980:01 to 2012:04 for the African economies. Shocks in z_t , the vector of endogenous variables can determine whether the economy is in a low or high inflation regime. Following Tsay (2005) under the null hypothesis (H_0), z_t follows a linear VAR model of the form:

$$z_t = \delta_0^{(j)} + \sum_{j=1}^p \psi_j z_{t-j} + \varepsilon_t^{(j)} \quad (6.7)$$

where $\delta_0^{(j)}$ is a $k \times 1$ vector of constant terms, ψ_j are $(k \times k)$ matrices of coefficients on the j^{th} lag of z_t and $\varepsilon_t^{(j)}$ is a $(k \times 1)$ vector of error terms, consisting of shocks from each of the variables in the model such that: $\varepsilon_t^{(j)} = [\varepsilon_t^y, \varepsilon_t^\pi, \varepsilon_t^m, \varepsilon_t^i, \varepsilon_t^{er}]'$, where $\varepsilon_t^{(j)} \sim i.i.d(0, \sigma^2)$ are Gaussian white noise error terms, while p is the optimal lag length which is determined by the AIC. The presumption of the linear VAR model is that there are no differences between regimes.

6.5.1 Conducting Inference tests about the Non-Linearity

The asymmetry in monetary policy is introduced by allowing the parameters of the linear VAR model in equation (6.7) to change, according to inflation, which is endogenously determined. This approach follows the study of Mojon (2008), Catik and Martin (2012) and Mandler (2012) who have used inflation as the threshold variable, denoted as (η_t) . This is reflected in the non-linear specification which assumes that z_t follows a multivariate two regime SETAR model.

$$z_t = \begin{cases} \delta_1^{(j)} + \sum_{j=1}^p \psi_j^1 z_{t-j} + \varepsilon_{1,t}^{(j)} & \text{if } \eta_{t-d} \leq \gamma \\ \delta_2^{(j)} + \sum_{j=1}^p \psi_j^2 z_{t-j} + \varepsilon_{2,t}^{(j)} & \text{if } \eta_{t-d} > \gamma \end{cases} \quad (6.8)$$

Equation (6.8) suggests that there are j for $j = 1, \dots, k$ regimes which are linear ($j = 1$) in the threshold space η_{t-d} but it is non-linear in the time space. By implication, the economy is in regime one (of the low inflation state) when the threshold relative to the delay lag is less than or equal to the threshold parameter; and is in regime two otherwise. For clarity of exposition, this is captured by the following threshold alternative hypotheses:

$$H_1^{(j)} = \begin{cases} \eta_{t-d} = 0 & \text{if } \eta_t \leq \gamma \\ \eta_{t-d} = 1 & \text{if } \eta_t > \gamma \end{cases} \quad (6.9)$$

where $\gamma = (\gamma_1, \gamma_2, \dots, \gamma_{j-1})$ is the unknown optimal inflation threshold representing a switch in regime. The threshold lag or the delay parameter, $d \in \mathbb{Z}$ is a non-negative integer and takes values from $d = 1, 2, \dots, p$ for the autocorrelation lag.

Non-linearity is captured by the fact that inflation is allowed to vary across regimes. The thresholds (γ_j) are undefined under the null hypothesis ($H_0 : z_t \sim SETAR(1)$) of the symmetric VAR model but are only identified under the alternative hypothesis ($H_1 : z_t \sim SETAR(j)$), $j > 1$. In order to resolve this problem which is often termed as “the nuisance parameter”, under the null hypothesis, the Hansen (1996) sup-Wald test over all possible thresholds is used to compute the likelihood ratio test.

6.6 Testing and Estimation of the TVAR Model

The inflation threshold values are estimated using sequential least squares approach. This follows the Hansen (1996, 2000) method for computing the sup-Wald test because it captures non-linearity in the observed data more than the

Andrews and Ploberger (1994) average and exponential Wald LM tests. The advantage of the Hansen (1996) method compared to other approaches such as the Tsay (1998) arranged autoregression⁶ is the fact that it determines the unknown threshold parameter, the number of regime(s) together with the delay lag. Given that the errors are *iid*,⁷ the Hansen (1996) test is a test with near optimal power to detect the presence of regime changes which is defined below.

$$F(\gamma_1) = \frac{SSR_0 - SSR_1}{\hat{\sigma}_1^2(\gamma_1)} = T' \left(\frac{\hat{\sigma}_0^2 - \hat{\sigma}_1^2(\gamma_1)}{\hat{\sigma}_1^2(\gamma_1)} \right) \quad (6.10)$$

Where T' is the effective sample size after adjusting for the degrees of freedom, while SSR_0 and SSR_1 are the sum of squared residuals from the SETAR(1) and the SETAR(2) models respectively, given the thresholds γ_j with their respective residual variances denoted as; $\hat{\sigma}_0^2$ and $\hat{\sigma}_1^2$. It follows that:

$$F_{LR} = \sup_{\gamma_1 \in \Gamma_d} F(\gamma_1) \quad (6.11)$$

where, Γ_d is the fractile of observations trimmed from the parameter space, γ_1 to ensure that each regime contains non-trivial proportions of the number of observations. Following Hansen (1996) and Balke (2000), 15% of the number of observations were trimmed off both ends and are not used to avoid over-fitting⁸ of the model.

6.7 Data

The data used in this chapter is same in the previous chapters. All data series are transformed to their growth rates, excluding non-trending series such as the interest rate and the exchange rate. By implication, the baseline model is estimated in levels of the variables. This follows Fuller's (1996, p.466) proposition (theorem 8.5.1) that differencing compromises asymptotic efficiency and results in loss of information from the TVAR model. See Catik and Martin (2012).

⁶The two methods differ in that Hansen (1996) uses a sequential least squares technique, while Tsay (1998) adopts recursive least squares in estimating the parameters of the model. This chapter uses the Hansen (1996) approach which is considered as the most widely used method in the literature. See Balke (2000), Altissimo and Violante (2001), Atasanova (2003) and Mandler (2012) for similar applications.

⁷The reason being that the linear VAR model is based on the likelihood ratio test assumes normality of the errors.

⁸Similar results were obtained by using 10% of the number of observations trimmed as a robustness check.

6.8 Empirical Results

6.8.1 Results of Non-Linear Univariate Inflation Threshold

Table 6.2 shows estimation results of the inflation threshold effect, simulated with bootstrapped probability values from the Hansen (1996) sup-Wald test for the inflation threshold model. The estimated thresholds ($\hat{\gamma}$) and the threshold lag length (\hat{p}) are obtained by the minimum sum of the squared residuals with 1000 replications.⁹ The null hypothesis of linearity against a non-linear alternative threshold model cannot be rejected for Botswana and Tunisia with the probability values exceeding the 5% level. These results indicate that switching may have negative implications on these economies, owing to their sectoral components and economic institutions; they are diamond and oil (petroleum) dependent economies respectively. One may suggest that there is a long-run relationship between variables in these economies which is implied by the non-existence of a threshold effect. In contrast to the above results, the empirical model presents strong evidence in favour of non-linearity in the inflation rate in Algeria, Ghana, Kenya, Nigeria, South Africa and Uganda for the observed data, with relatively high inflation thresholds. The case of Uganda, with an estimated inflation threshold of 82.98% is partly explained by the macroeconomic instability in the 1980's and the early 1990's brought about by regime switching (Saxegaard, 2006). In Kenya, the lags on inflation, was brought about by inflationary expectation effects on monetary policy due to the series of negative supply shocks, especially those in the early 1990's (Durevall and Sjo, 2012). The high threshold lag order is explained by the presence of non-linearity in the inflation rate and this effect is greater where the estimated thresholds are larger.

⁹This is because the asymptotic distribution of the sup-Wald test statistics are non-standard and not chi-squared. Bootstrapped replications are used to produce asymptotically correct p-values of the threshold estimates.

Table 6.2: Univariate Test Results of Inflation Threshold Non-Linearity.

Country	sup-Wald Stats	Bootstrapped PV's	Estimated thresholds (%)	(\hat{p}, \hat{d})
Algeria	19.550	0.006	$\hat{\gamma} = 20.429$	(2,1)
Botswana	6.769	0.736 ⁺	$\hat{\gamma} = 12.645$	(2,2)
Ghana	53.338	0.000	$\hat{\gamma} = 14.102$	(5,2)
Kenya	23.931	0.012	$\hat{\gamma} = 14.381$	(6,5)
Nigeria	21.856	0.003	$\hat{\gamma} = 26.574$	(6,1)
South Africa	14.805	0.043	$\hat{\gamma} = 10.965$	(2,1)
Tunisia	9.451	0.317 ⁺	$\hat{\gamma} = 6.498$	(2,1)
Uganda	38.139	0.000	$\hat{\gamma} = 82.985$	(6,1)

Note: + denotes that the null of no threshold behaviour cannot be rejected.

Results are obtained using the RATS software.

Table 6.3: Inflation Thresholds and Average Inflation for the period 1980:01 to 2012:04.

	Optimal inflation thresholds	Summary statistics for Inflation			
Country	Estimated thresholds (%)	Mean	Median	Min	Max
Algeria	$\hat{\gamma} = 20.429$	9.86	6.07	0.04	33.08
Botswana	$\hat{\gamma} = 12.645$	9.89	9.22	5.63	17.90
Ghana	$\hat{\gamma} = 14.102$	29.84	20.34	3.18	143.97
Kenya	$\hat{\gamma} = 14.381$	13.06	11.31	-1.80	56.36
Nigeria	$\hat{\gamma} = 26.574$	20.52	13.20	-2.74	87.89
South Africa	$\hat{\gamma} = 10.965$	9.74	9.42	0.43	19.25
Tunisia	$\hat{\gamma} = 6.498$	4.34	4.02	1.19	8.85
Uganda	$\hat{\gamma} = 82.985$	36.18	9.96	-4.32	275.62

Note: Min & Max are minimum and maximum value of the series.

As a robustness check, comparison is made between the estimated inflation thresholds with the average inflation for the period 1980:01 to 2012:04. These results are reported in Table 6.3, together with the summary statistics for inflation, drawn from Chapter 4. These results indicate that the inflation thresholds are less than the maximum inflation for this sample of African economies and does not cast doubts on the estimation technique.¹⁰ These results are relative to the inflation rate, contingent on shocks to inflation in a univariate model. In the next section, we examine the implication on optimal inflation threshold levels

¹⁰Hansen (2000) found that the estimated thresholds are super-consistent.

in a multivariate framework, which encompasses all the variables in z_t . By so doing, we seek to address the following hypothesis: are monetary policy targets on inflation for the African economies based solely on shocks to inflation or do we need to consider the dynamic effects of other key macroeconomic variables?

6.8.2 The Results of the Multivariate Non-Linearity Tests

Given that the literature is not clear about the arrangement of the variables in the multivariate TVAR models, firstly, we determine the optimal lag lengths with a maximum lag, $p = 8$ for different orderings of inflation. These results are reported in Table 6.4 for the AIC based on the theoretical framework proposed by Pitarakis (2006). Calza and Sousa (2006) also found that the threshold is dependent on the information criteria. The lag lengths are chosen as those that minimize the AIC and are similar in all three cases. There is evidence that the optimal lag length does not depend on the ordering of the variables in the multivariate TVAR model. This study is the first to have considered implications of different optimal lag orders for the TVAR model, in African economies.

Following Balke (2000), Mandler (2012) and Catik and Martin (2012) we follow the results associated with column four in Table 6.4 for ordering the variables, which is standard practice in the literature as; $z_t = [y_t, \pi_t, m_t, i_t, er_t]'$. This is also consistent with the theoretical proposition that nominal rigidities arise from the output gap, while prices are flexible in the African economies (Kandil, 2008).

The results for the multivariate TVAR model are presented in Table 6.5, allowing for the dynamic relationship between inflation and the monetary policy variables. The thresholds are estimated with 1000 bootstrapped simulations and 0.15 trimming, corrected for heteroskedastic errors (White, 1980). The results reveal that after allowing for the dynamic interaction between inflation and monetary policy variables, the magnitude of the estimated inflation thresholds are smaller than those estimated from the single equation inflation threshold model. There is evidence to suggest that these results are consistent with the monetary policy frameworks of the African economies. This is due to the fact that the estimated inflation thresholds closely match the inflation targets for the sample of African economies. The estimated threshold is much lower in Uganda in the multivariate non-linearity test, can be attributed to two reasons. It showed that the introduction of monetary targeting framework by the BoU in 1993 brought down inflation to lower levels. There is also evidence to suggest that the recently introduced ITL, to target the CPI at 5% has reduced the variance of inflation

in Uganda. Therefore, the dynamic interaction between inflation and monetary policy variables strongly influence monetary policy targets on inflation for the African economies.

Table 6.4: Estimated Lag Lengths for Different Orderings of Inflation.

Country	Inflation first	Inflation last	Inflation ^w	Estimated AIC Value
Algeria	2	2	2	275.867
Botswana	2	2	2	827.482
Ghana	5	5	5	769.362
Kenya	6	6	6	-54.774
Nigeria	2	2	2	815.527
South Africa	2	2	2	296.682
Tunisia	2	2	2	-187.084
Uganda	6	6	6	1400.679

Note: Inflation^w refers to the following ordering of variables $z_t = [y_t, \pi_t, m_t, i_t, er_t]'$
Results are obtained using the RATS software.

Table 6.5: Multivariate Threshold Non-Linearity Test.

VAR: Output gap, Inflation, Money Supply, Policy Interest Rate and Exchange Rate				
Country	LM Statistics	Bootstrapped PV's	Estimated thresholds (%)	Evidence
Algeria	28.617	0.000	$\hat{\gamma} = 5.201$	Yes
Botswana	31.777	0.000	$\hat{\gamma} = 9.170$	Yes
Ghana	15.245	0.000	$\hat{\gamma} = 13.163$	Yes
Kenya	30.352	0.000	$\hat{\gamma} = 10.697$	Yes
Nigeria	-	1.000 ⁺	$\hat{\gamma} = 6.113^+$	No
South Africa	24.338	0.000	$\hat{\gamma} = 7.013$	Yes
Tunisia	21.637	0.000	$\hat{\gamma} = 4.689$	Yes
Uganda	15.401	0.011	$\hat{\gamma} = 6.741$	Yes

Note: + means the null of no threshold behaviour cannot be rejected at the 5% level
LM test for no threshold against the alternative of threshold effect.

Comparing these results with previous studies from the African economies which have used inflation as the threshold variable, Khan and Senhadji (2001) and Frimpong and Oteng-Abayie (2010) found threshold inflation levels for Ghana of 11% for the period 1960 – 1998 and 1960 to 2008 respectively. Our estimated results suggest an average of 13.163%, over the period 1980:01 to 2012:04. This result reflects the fact that the magnitude of inflation threshold levels has been

rising in Ghana due to rising inflationary expectations over the past years and the current inflation rate stands at 14.5% (in March 2014 estimates). Phiri (2012) found an inflation threshold level of 8% between 2000 to 2010 for the South African economy. This matches closely with our estimated inflation threshold for South Africa which is 7.013%, taking into account our estimation period is extended to 2012:04. One may be prompted (perhaps rightly so) to say that monetary policy has been effective in South Africa in reducing inflation to the target level of 3-6%. Inflation in Uganda has reduced to single-digit due to an effective monetary policy framework, following the introduction of an ITL. The next section introduces the impulse responses for the low and high inflation regimes.

6.9 Impulse Responses

The existence of a threshold effect implies that regime-dependent impulse responses can be generated. This is to capture the asymmetric distribution of shocks to the system, with respect to the inflation threshold. The advantage of using regime-dependent responses over the generalized impulse responses¹¹ with respect to Koop et al (1996) and Pesaran and Shin (1998) is that the former approach considers that the endogenous transition of the economy are based on regimes which separates the economy into either the low or high states. Whereas, the latter method assumes that the probability of changing regime is negligible. This implies that the system remains in the same regime for analysing the impact of a shock to the economy (Saxegaard, 2006). The second approach is unattractive given the existence of a threshold effect.

The IRF are simulated with 500 Monte Carlo replications and with 0.16 and 0.84¹² quantiles of the empirical distribution representing the confidence interval. This is used in order to conduct proper inference about the true significance of the impulse responses (Lucchetti, 2006). These results are reported in Figures 6.2 to 6.9, plotted with their upper and lower error bands following a structural one SD shock to the monetary policy. This is identified by changes in the short-term interest rate in response to changes in the mean of inflation over a 24th quarter horizon (which is represented by the horizontal axis), while the vertical axis represents the magnitude of the shock from monetary policy. The figures

¹¹The generalized impulse responses have come under attack in recent years because they are invariant of the ordering of variables in the VAR model, and are based on complex identifying assumptions about the realization of macroeconomic shocks (Kim, 2012).

¹²This credible confidence interval compares to the study by Catik and Martin (2012) which has used 0.025 and 0.975. Using a higher percentage of the confidence intervals restricts the true significance of the impulse response.

show that the response of an interest rate shock is stronger when inflation exceeds its threshold value. Non-linearity effects to the system in the economy are initially in one regime and then switches to another regime due to shocks to the system propagated through the inflation threshold.

6.9.1 Low Inflation Regime

It emerges from the empirical results that in the low inflation regime, economic agents slowly adjust their expectations regarding inflation. This is consistent with evidence from the literature that inflation has a mild effect below its threshold level (Frimpong and Oteng-Abayie, 2010). To be precise, a negative monetary policy shock decreases the interest rate and inflation is then insignificant. Through the multiplier effect of investment in response to lower interest rate, there is a strong initial response in the output gap in the contemporaneous period to the shock from monetary policy.

In Algeria the output gap takes on average 8 quarters following the shock from monetary policy, to return to zero due to the gradual lowering of the interest rate. The response of the interest rate is positive, which rises by 0.05 to 0.30% on impact and has the effect of offsetting the negative exchange rate shock (depreciation of the exchange rate). The response of inflation and commodity prices are insignificant as economic agents lower their expectations about inflation. Similar results are obtained in Botswana,¹³ where inflation and commodity prices are insignificant in the low inflation regime as the interest rate gradually respond to shocks. The price puzzle¹⁴ is negligible, although the monetary policy shock is manifested by a depreciation of the exchange rate. This is because the magnitude of the interest rate increases by 0.43 to 0.6% on impact and outweighs the effects of the negative exchange rate shock. The increase in the output gap persists from the fifth quarter of the shock to monetary policy.

In Ghana, South Africa and Uganda, in the low inflation regime, the response of the variables is mild and the speed of adjustment from the shock to monetary policy (through changes in the interest rate) is slow. The output gap in Ghana is positive and reaches its peak after 2 quarters following the shock to monetary

¹³Although the univariate model suggests that inflation is linear, perhaps due to the stability of the sales of its diamonds, there is evidence of non-linearity in inflation for the multivariate model (results presented in Table 6.5). This analysis suggests that monetary policy has a much stronger effect in Botswana when inflation and monetary policy variables are combined than assuming a univariate model of the inflation threshold.

¹⁴This is the finding that a rise in interest rate leads to an increase, rather than a decrease in inflation.

policy. An exchange rate depreciation leads to an increase in inflation by approximately 0.6% from the first to the third quarter to the shock, but after this period, inflation starts declining below 0.2% following an interest rate shock. The money supply is insignificant and the interest rate rises by 2.4% from the contemporaneous period to the shock to monetary policy. One interesting feature about this result in Ghana is that the rise in the short-term interest rate is below 0.5% after the 10th quarter of the shock, until monetary policy observes that inflation had begun to decrease. In South Africa, the output gap is positive following the contemporaneous period of the shock to monetary policy. The money supply is insignificant and inflation is constant at a 0.5% rise after the shock to monetary policy. The interest rate is stable at a 1.2% increase, which occurred due to a 0.25% appreciation of the exchange rate after the shock to monetary policy. In Uganda, in the low inflation regime a positive monetary policy shock raises the interest rate by 0.1% to 3.5% and the exchange rate declines (appreciate) with a delayed overshooting after the shock to monetary policy. The effects of a monetary contraction through a rise in interest rate are a fall in the output gap and inflation declines, until the 9th quarter when inflation starts to rise above zero. The response of monetary policy are through slow increases in the interest rate due to lower inflationary expectations, which is manifested by a gradual return of the output gap to zero for the period after the shock to monetary policy.

The impact of the output gap shocks in Kenya are larger and more persistent in the low inflation regime. Inflation is insignificant and the exchange rate is positive from the first period contemporaneous to the shock to monetary policy. In Kenya, it is observed that the money supply is insignificant due to a strong response from monetary policy which increases the interest rate by 0.1 to 0.36% on impact and therefore cancels out the effects of the exchange rate depreciation on inflation.

It is not surprising that the response of the variables in Nigeria in the low inflation regime are insignificant given the fact that linearity was not rejected in the multivariate threshold model. This result suggests that oil dependent economies such as Nigeria aim to maintain stable inflation rates as switching may have negative impacts on their economy. By implication, the high inflation regime yields results which are similar to the symmetric VAR model. This is characterized by a fall in the output gap and the money supply below zero from the period following the shock to monetary policy. The increase in inflation by approximately 1.4% after the 8th quarter to the shock in monetary policy may have resulted from a 0.15% depreciation of the exchange rate.

In Tunisia, in the low inflation regime, the output gap is positive up to the 6th period contemporaneous to the shock from monetary policy. The money supply is insignificant in response to the shock to monetary policy, but inflation is positive on impact. This may be explained by the fact that part of the increase in inflation is a side effect of the accommodative monetary policy¹⁵ which may have resulted from an increase in the rate of growth in the money supply. The monetary policy interest rate slowly rises due to a constant nominal appreciation of the exchange rate (with a delayed overshooting). The magnitude of the interest rate increase is slow in Tunisia, which suggests that the interest rate are used as an anchor for the growth rate in the money supply which is currently targeted at 2%.

6.9.2 High Inflation Regime

In the medium-term, inflation rises along with its determinants such as commodity prices. This eventually puts the economy into the high inflation state. Inflation has a considerable impact on monetary policy interest rate when it exceeds the estimated threshold values. The response of monetary policy in the high inflation regime is characterized by the following features. Firstly, the magnitude of the interest rate increase is much stronger in the high inflation regime than in the low inflation regime. This reveals asymmetric effects in monetary policy interest rate in terms of the adjustments to bring down inflation to low levels. Secondly, the output gap falls following an interest rate shock in response to inflationary expectations. These results are consistent with evidence in the literature; see Mandler (2012) and Balke (2000) that the policy makers react strongly only when the asymmetric effects on macroeconomic variables impinges on the credibility of the central bank to conduct monetary policy, in terms of stabilising the economy.

In Algeria, in the high inflation regime, inflation is persistent, which is constant at a 0.4% increase and commodity price shocks are positive following the shock to monetary policy. The increase in inflation may have resulted from the negative exchange rate shock, which put upward pressure on the price level, and also because Algeria has not formally introduced inflation targeting. Monetary policy has a stronger effect to an inflation shock, which is reflected by a fall in the output gap below zero but eventually returning to equilibrium after 13 quarters following the contemporaneous period of the shock. The magnitude of the interest rate increase as a result of the shock to inflation is double that in the low

¹⁵Castelnuovo and Surico (2010) argues that the price puzzle emerges because of accommodative monetary policy.

inflation regime. The interest rate rises by 0.5% to 1.0% following the monetary contraction. This result suggests that monetary policy has an asymmetric effect when inflation exceeds its threshold value.

In Botswana, the impact of commodity price shocks are mild, but inflation takes on average 7 quarters to return to zero following an interest rate shock. The price puzzle is partly due to lags in monetary policy which is explained by the conventional monetary policy maker's decision to react gradually to shocks in inflation (Orphanides and Wilcox, 2002). It takes on average 3 quarters for the output gap to start falling below zero due to the monetary contraction that increases the short-term interest rate by 0.7% on impact following the contemporaneous period of the shock. The response of the interest rate is mild, after the 14th quarter horizon, it rises slowly as the output gap gradually return to equilibrium after this period following the shock to monetary policy.

In Ghana, while the response of monetary policy is mild in the low inflation state, conversely, there is a stronger response of monetary policy in the high inflation regime. This is manifested by a sharp rise in the short-term interest rate by 1.0% to 2.5% over the twenty-fourth quarter horizon. The speed of adjustment is quicker in the high inflation regime as it takes only 5 quarters for the output gap to return to equilibrium and reaches its peak after the 8th period horizon from the shock to monetary policy.

In Kenya, in the high inflation regime, inflation initially rises above 2% and persists up to the sixth quarter from the shock to monetary policy. This result is consistent with studies on the African economies. Particularly, Durevall and Sjo (2012) found that the reduction in inflation in Kenya is slow, which is also referred to as inflation inertia after the shock to monetary policy. Compared to the low inflation regime, a rise in the interest rate by 1.0% leads to a contraction in the output gap. The interest rate increases slowly at less than 0.5% after the 11th period following the shock to monetary policy and the exchange rate appreciates on impact. This means that the positive interest rate shocks are likely to be small and not very persistent, as the output gap takes on average 17 quarters to return to equilibrium. According to Woodford (2003), this is to enable the policy maker to smooth the effects of policy over time by affecting private sector expectations. The results also reflect the fact that the monetary policy framework in Kenya is based on the hybrid ITL, which considers the importance of the exchange rate in an inflation targeting framework (Roger et al, 2009).

With one exception, monetary policy shocks have symmetric rather asymmetric effects in Nigeria, although inflation rises in the high inflation regime. Results reveal that in South Africa, in the high inflation regime, the fall in the output gap is more persistent and larger than those observed in the low inflation regime. A positive monetary policy shock that raises the interest rate at 1.25%, in turn reduces the output gap. The output gap reaches its minimum after the 8th quarter following the shock to monetary policy and the money supply is insignificant. The monetary policy reaction is observed by reducing the interest rate below 0.25% rise after the 12th quarter from the shock to monetary policy when inflation starts declining and the output gap gradually returns to equilibrium. This result is indicative of a strong monetary policy framework, coupled with the inflation targeting framework which has been implemented by the SARB.

In Tunisia the response of the variables is mild in response to a positive interest rate shock. One feature deserves attention in the case of Tunisia. Although monetary policy has been conducted based on targeting the rate of growth of the money supply rather than the short-term interest rate, it appears that the interest rate is becoming more important in the monetary policy framework in Tunisia. This is evident from the magnitude of the interest rate increase by 0.10% and the exchange rate appreciates on impact after the shock to monetary policy.

Finally, monetary policy has a stronger effect in Uganda when inflation exceeds its threshold value of 6.741%. These results indicate that the speed of adjustment from the non-linear shock is faster in the high inflation regime, as compared to the low inflation regime. The monetary policy short-term interest rate rises by 0.5% to 3.0% on impact, which brings down inflation to 4% after the 5th quarter after the shock to monetary policy. The depreciation of the exchange rate is mild following the shock to monetary policy, while the money supply is insignificant.

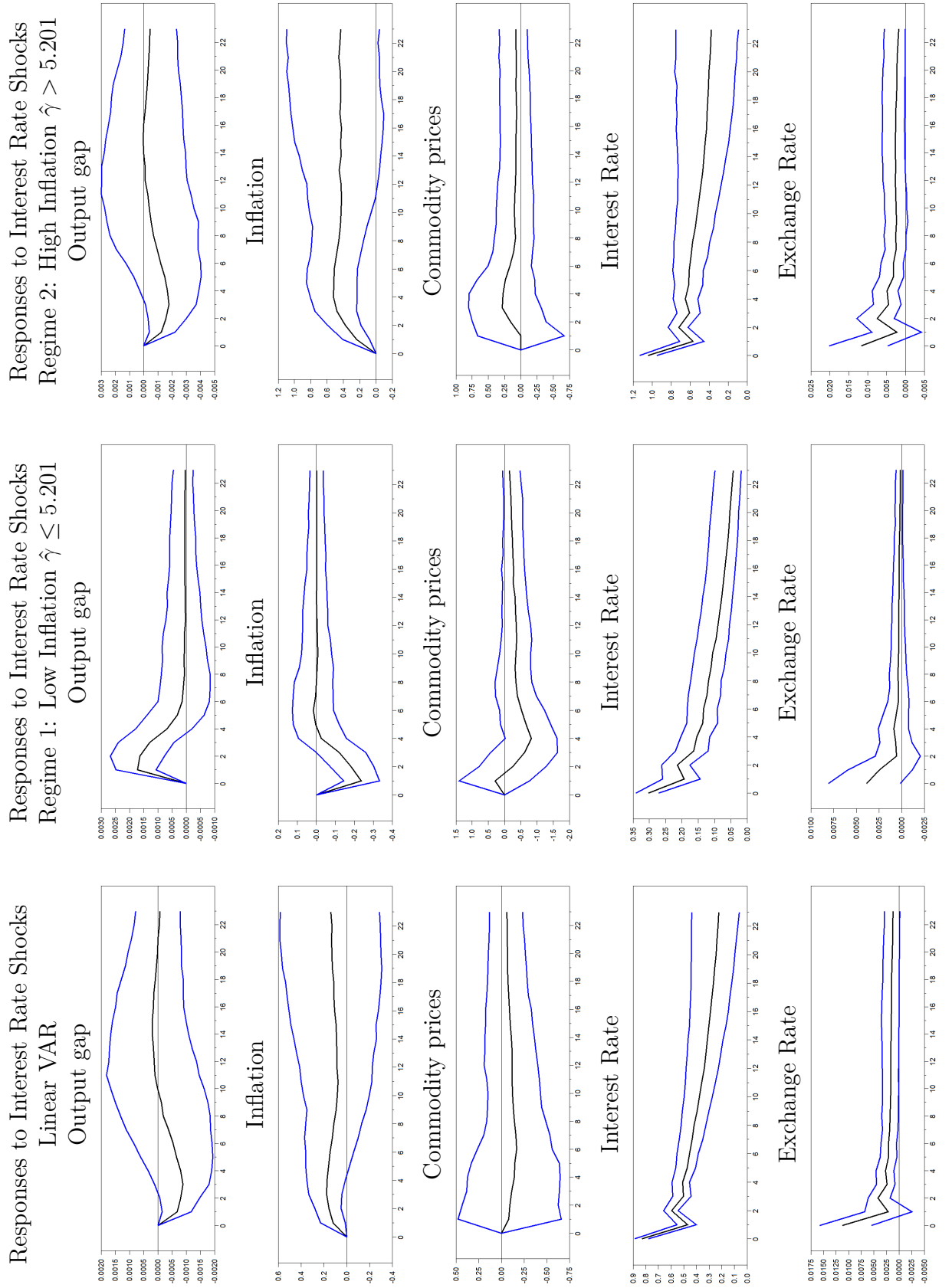


Figure 6.2: Algeria: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

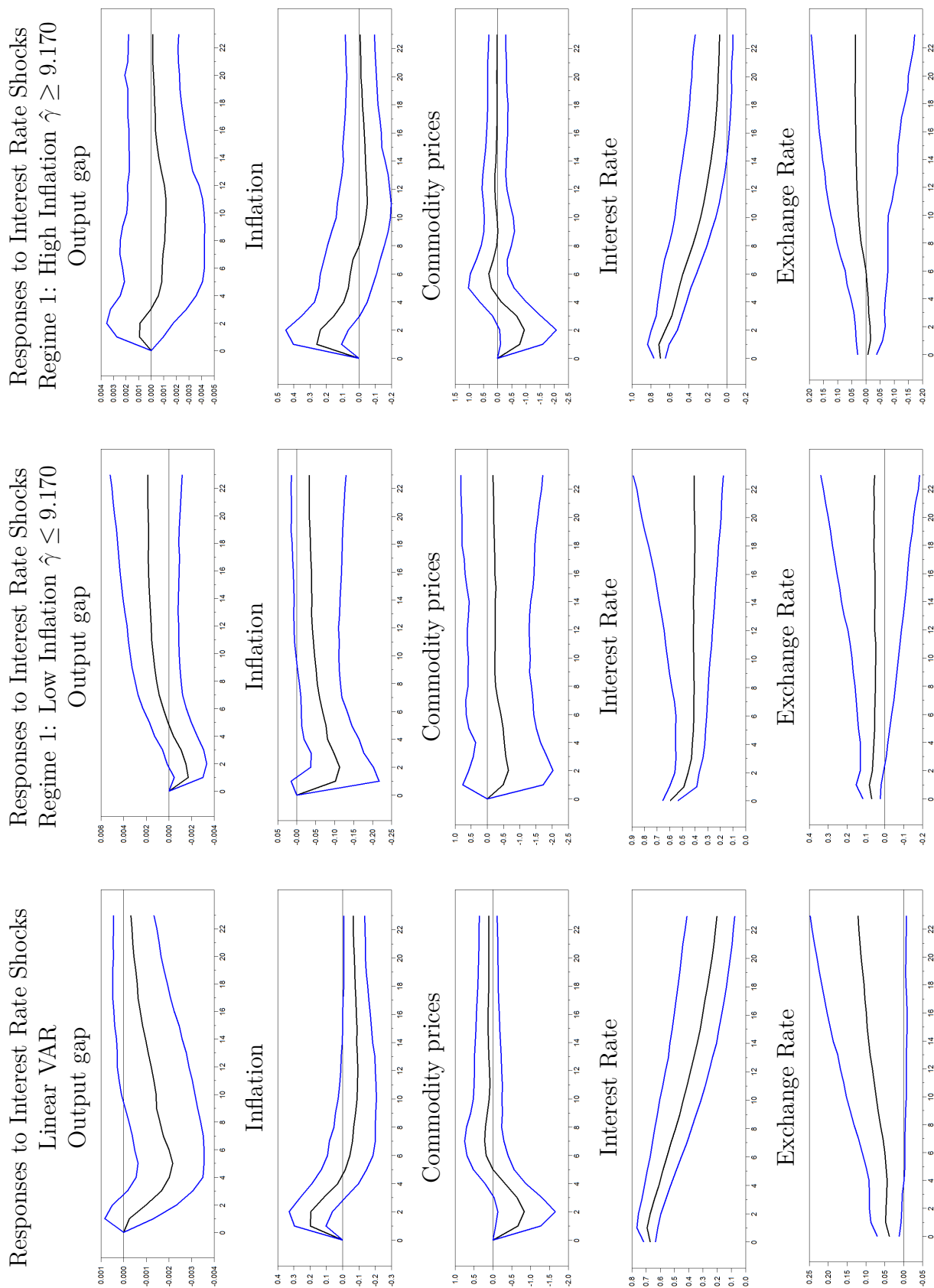


Figure 6.3: Botswana: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

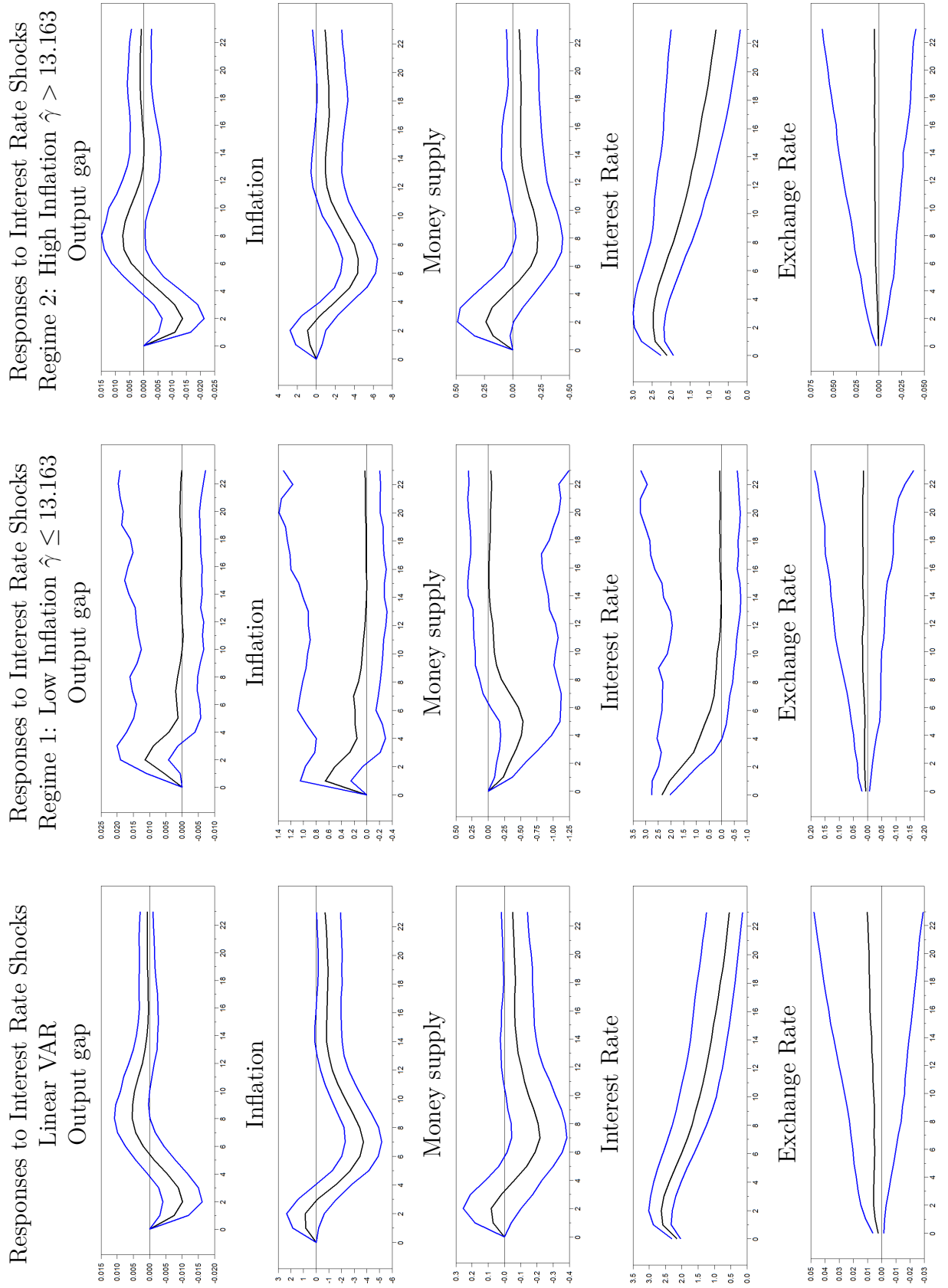


Figure 6.4: Ghana: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

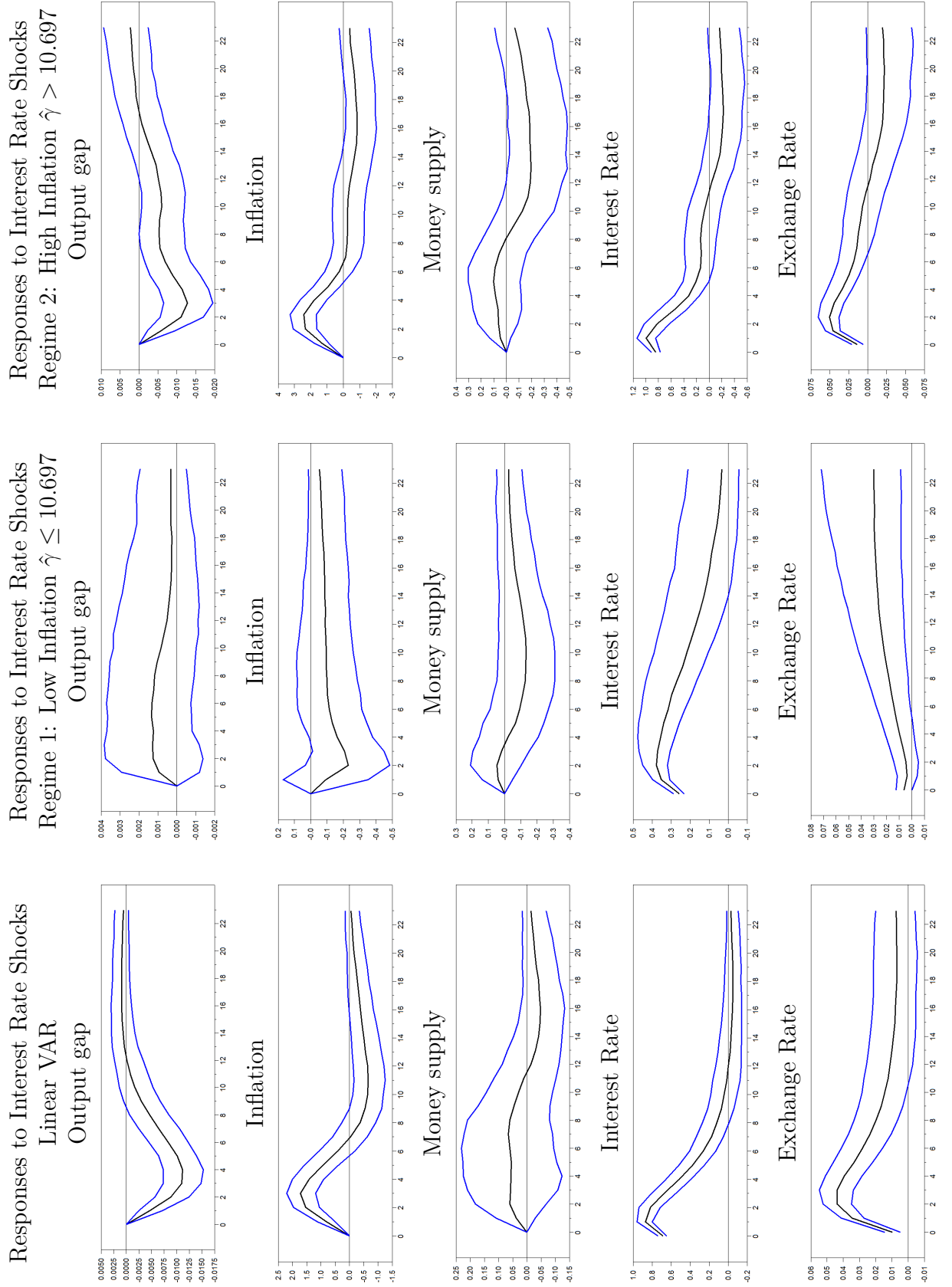


Figure 6.5: Kenya: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

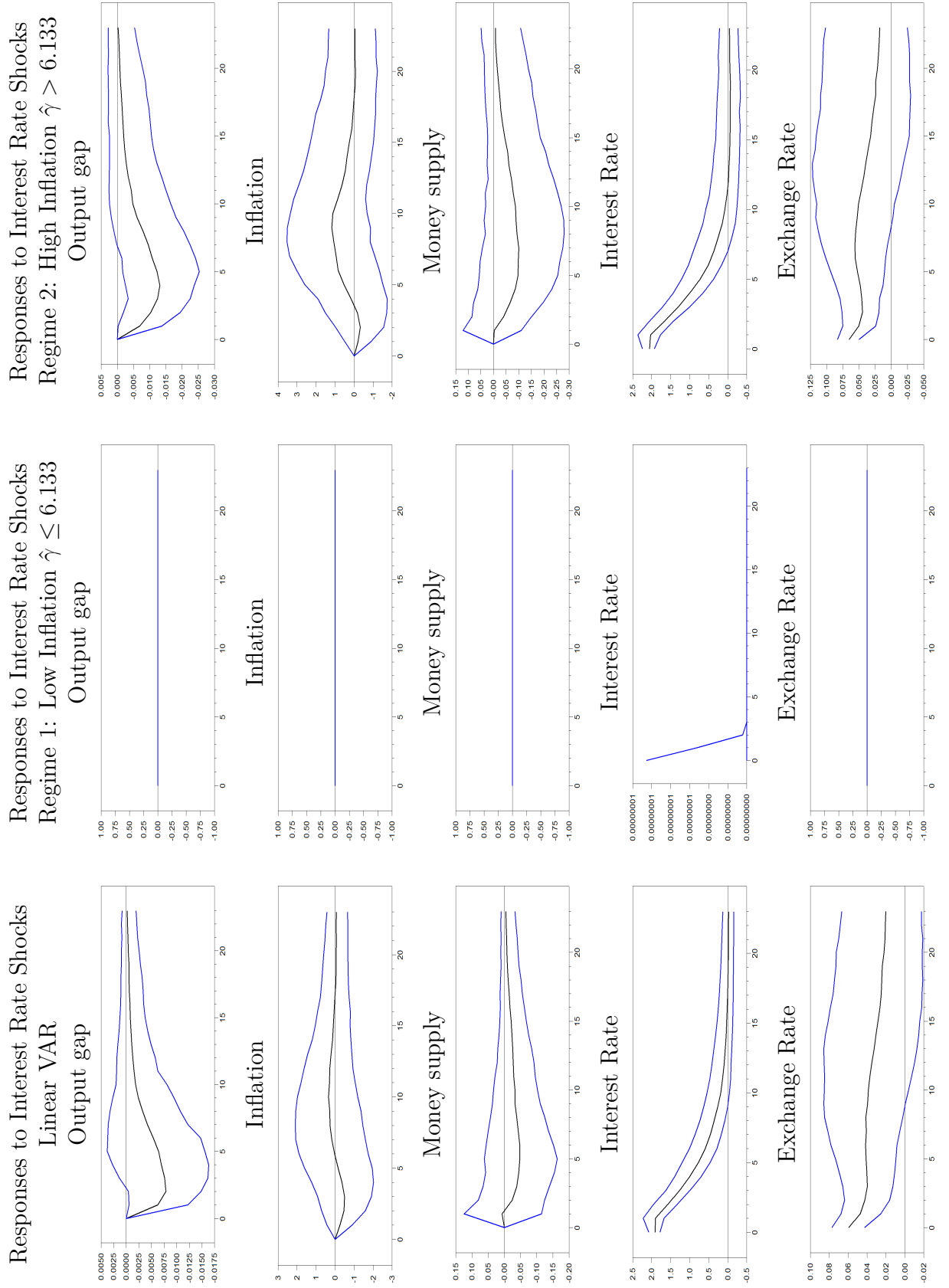


Figure 6.6: Nigeria: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

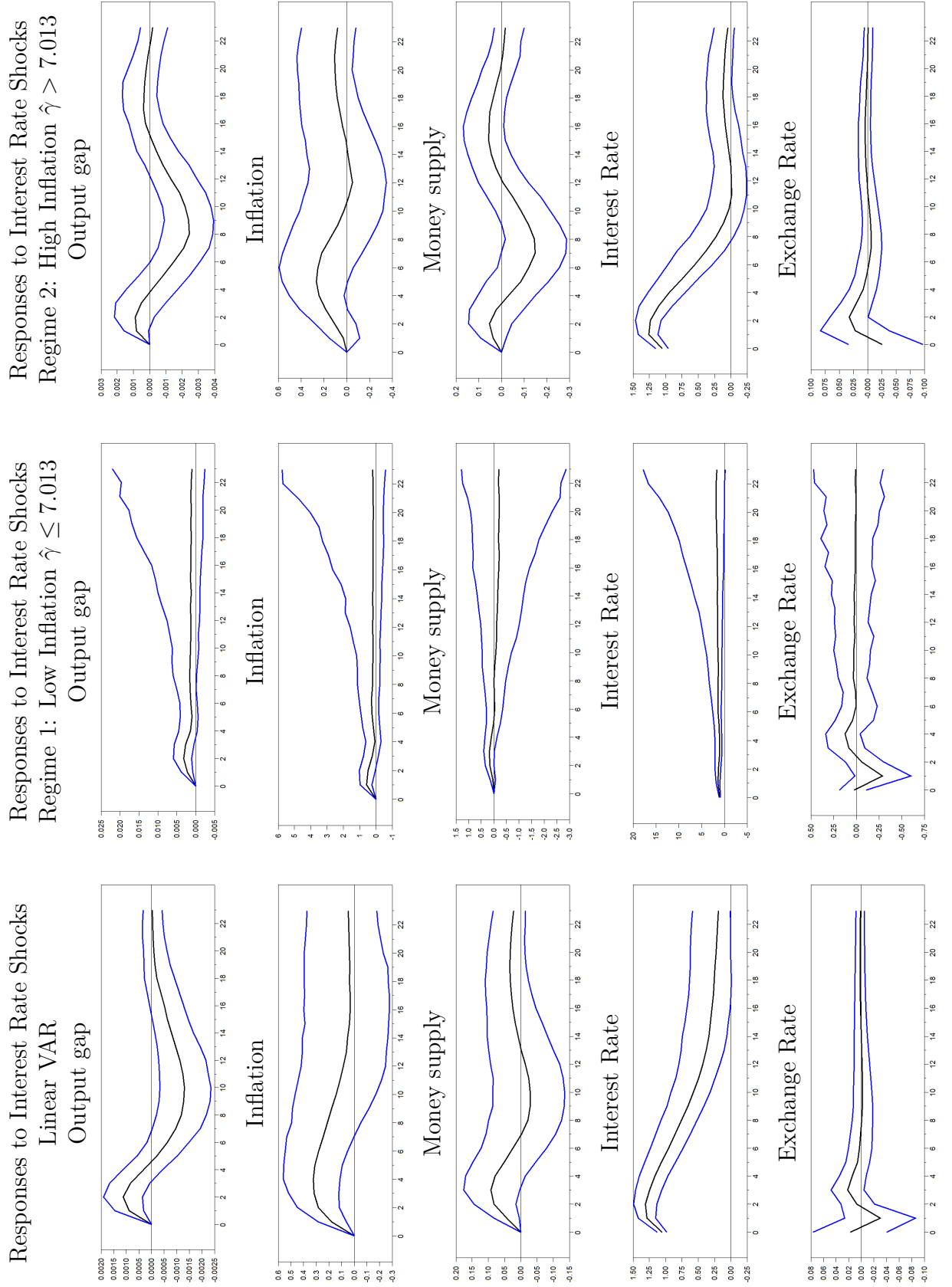


Figure 6.7: South Africa: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

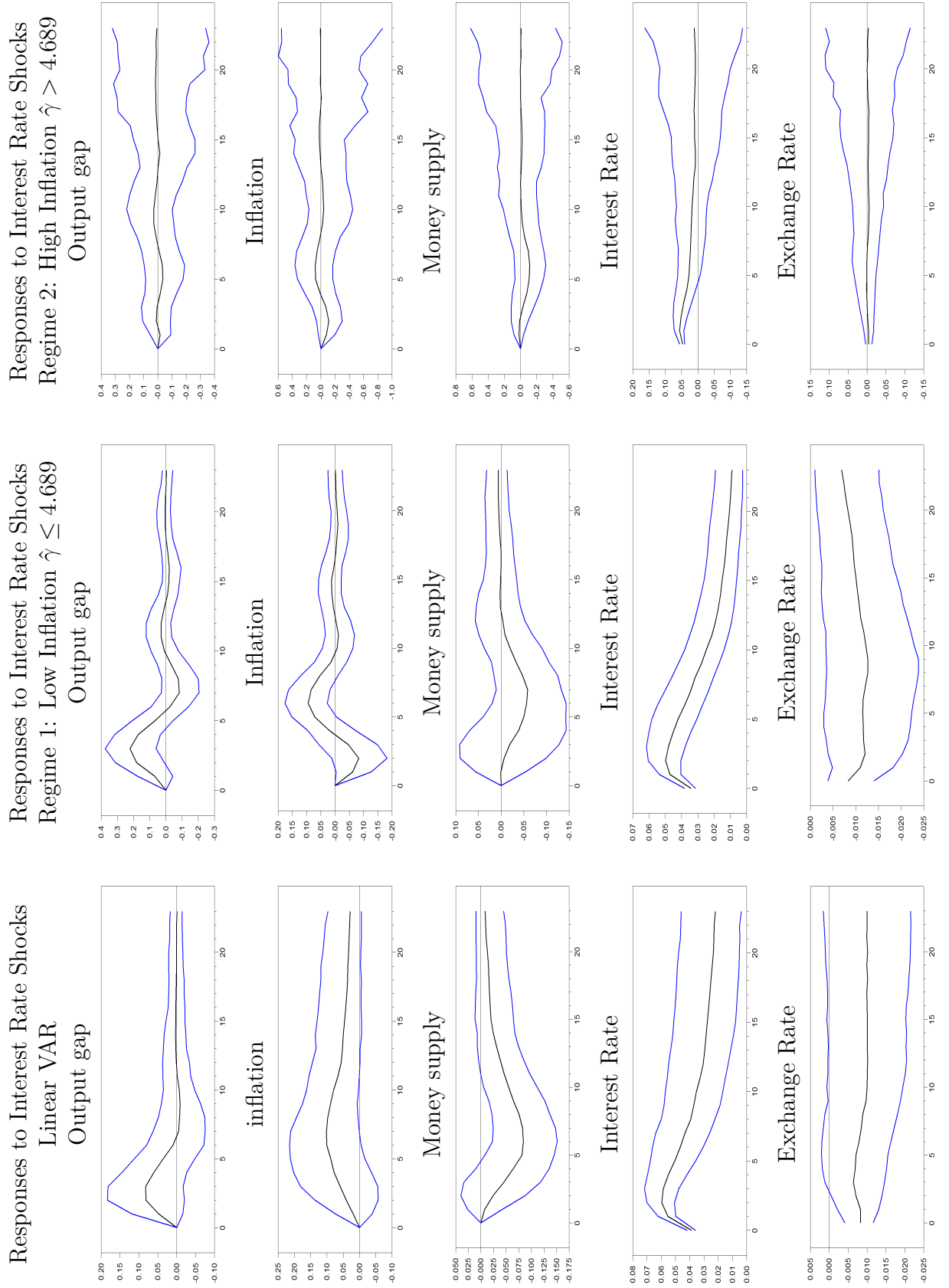


Figure 6.8: Tunisia: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

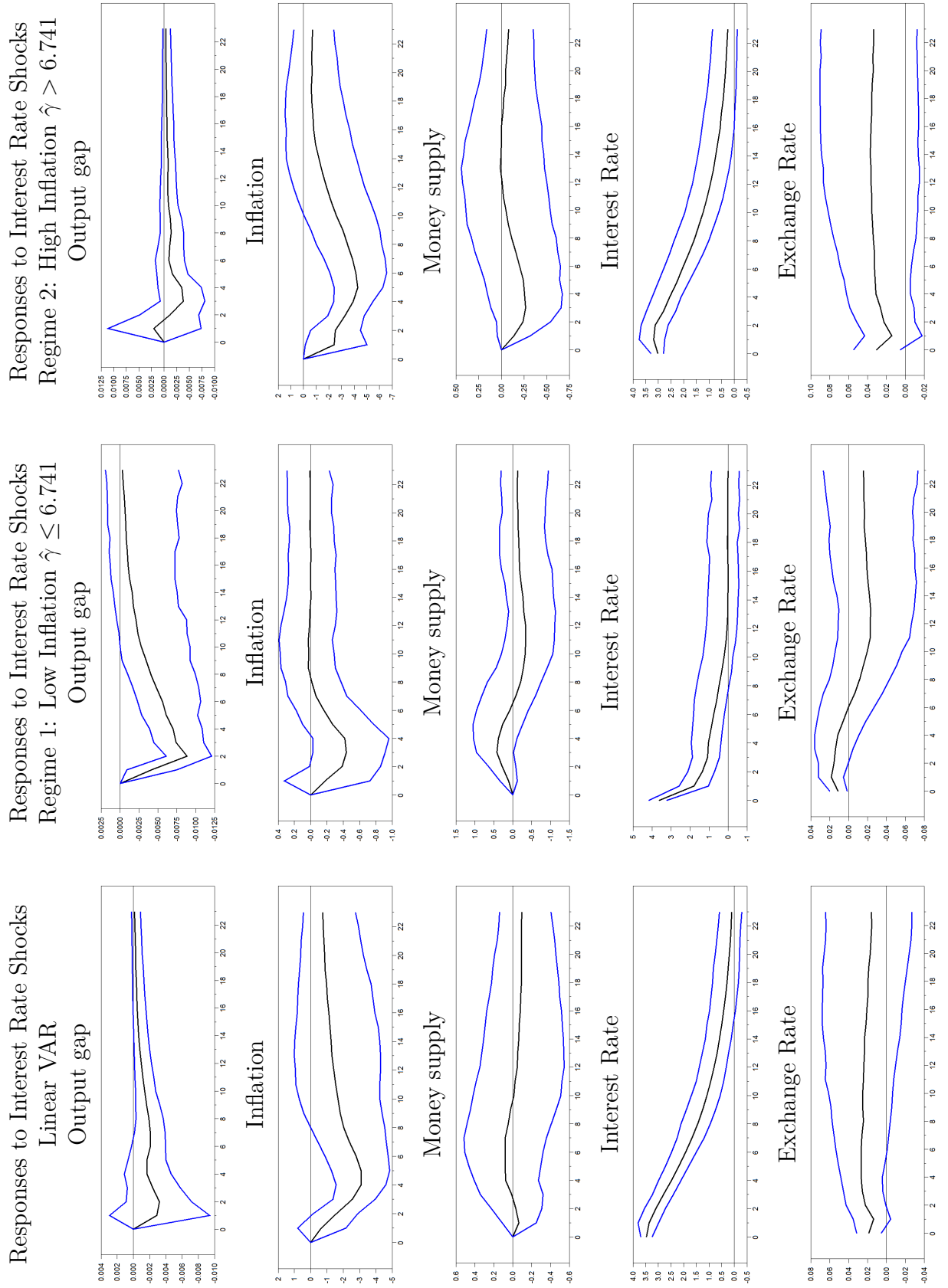


Figure 6.9: Uganda: Non-Linear Impulse Responses to one SD Monetary Policy Shocks.

6.10 Conclusions and Policy Implications

The purpose of this chapter was to determine the optimal inflation rate for the African economies at which inflation affects the monetary policy framework, caused by regime switching. Inflation regimes are endogenously determined while monetary policy is identified by shocks to the interest rate. This was achieved by empirically modelling inflation and monetary policy variables, using data from 1980:01 to 2012:04. The contributions of the chapter (research strategy) are three fold. Firstly, we employed a non-parametric test, based on the assumption that the form of non-linearity of inflation is unknown, but found some evidence in support of non-linearity. Secondly, we extended the non-parametric method, to allow for different types of non-linearity by estimating a univariate TAR model for inflation and its multivariate threshold form. The research strategy involved testing for thresholds and selecting and estimating a TVAR model, for the sample of African economies.

The results reveal that after allowing for the dynamic interaction between inflation and monetary policy variables, the estimated thresholds are more consistent with the inflation targets of the African economies than those estimated from the single equation inflation threshold model. It is imperative, therefore that the subsequent inflation targeting frameworks will stabilize the economy and achieve monetary policy objectives. Thirdly, given the existence of a threshold effect, regime-dependent impulse responses were generated and two inflation regimes were analysed, based on the critical values of the inflation thresholds. In the low inflation regime, economic agents lower their expectation about inflationary pressures.

The results indicate a strong asymmetric response in the monetary policy interest rate, which is more effective in the high inflation regime and has larger effects than do expansionary shocks. The analysis suggests that monetary policy in the African economies is regime-dependent, characterized by changes in inflation. The output gap declines temporarily, on average in the high inflation regime due to a strong effect from monetary policy shocks. Monetary policy shock (through changes in the interest rate) has a much stronger effect on the output gap and inflation than the exchange rate. This study finds that inflationary tendencies may have been compounded by the depreciation of the exchange rate putting upward pressure on the price level due to the weak exchange rate channel of the monetary policy transmission mechanism in the African economies. As a result of the negative exchange rate shocks, the interest rate is held higher by the mon-

etary authorities in response to an expected depreciation of the exchange rate. The conclusion drawn from this study reveals that asymmetry arises from the dynamic interaction between inflation and the monetary policy variables. As there has been a change in the transition mechanism of the monetary policy shocks, such that the authorities strongly implement policy changes when inflation goes beyond a certain threshold.

Chapter 7

Monetary Policy Transmission Mechanisms in African economies: A Bayesian VAR Approach

7.1 Introduction

In the previous empirical chapters, the monetary policy transmission mechanism for the sample of African economies was examined using the SVAR and TVAR frameworks. The SVAR approach determines the transmission mechanism of monetary policy by imposing restrictions on the dynamic characteristics of the structure of the African economies, based on economic theory on the distribution of shocks to the economy. The plausibility of the SVAR method rests in the fact that by imposing restrictions, it helps to reduce the dimensions of the model, in order to resolve the overfitting problem, which is often considered as the main flaw with unrestricted VAR models. The advantage of the TVAR approach was to determine optimal inflation thresholds and the asymmetric effects of monetary policy with respect to inflation, analysed by the regime-dependent IRF. This chapter adds a third technique to the above two methods in the form of the BVAR to explore the monetary policy performance of the sample of African economies. The BVAR approach was introduced into studies of applied macroeconomics also as a means of addressing the problem for the increase in the lag length to reduce the dimensions of the model, in terms of the degrees of freedom (Doan et al, 1984). Banbura et al (2010) have developed a Bayesian shrinkage or parsimonious approach for models containing large data sets. This method uses the average of the MSFE from a model consisting of the output gap, in-

flation and monetary policy interest rate as a potential indicator for the overall tightness of the economy. Unlike the SVAR and TVAR, the BVAR treats parameters as random variables by assigning prior (conditional) probabilities to them, in order to account for the uncertainty in monetary policy and beliefs about the central bank's expectations to macroeconomic shocks. This is based on the likelihood function of parameters following the Bayesian estimation principle and conditional on the set of macroeconomic variables for evaluating changes to the economy. The problem of identification in structural macroeconomic models is converted to a specification of informative priors which are the hyper-parameters in Bayesian modelling (Giannone et al, 2012).

Over recent years, predicting future developments in macroeconomic variables has become increasingly important in terms of monetary policy decision making by most central banks. This is because continuous high inflation persistence in most countries has caused uncertainty in the conduct of monetary policy. In particular, it has raised questions such as: what is the central bank's prior belief about the impact of inflationary shocks on the economy? How does monetary policy respond to shocks from the economy after receiving updated information from macroeconomic variables? The answers to these questions can be provided using the BVAR estimation procedure which was first advocated by Litterman (1984, 1986) and Doan et al (1984) as a method for evaluating changes in the economy. This is to say the development of Bayesian estimation has proven popular for policy analysis and prediction because subjective beliefs are defined in terms of conditional probabilities. This means Bayesian analysis combines prior information with the sampling information contained in the data (Todd, 1984; Giannone and Reichlin, 2006 and Koop, 2010). It is also the case that Bayesian analysis produces good forecast estimates of macroeconomic variables (Kadiyala and Karlsson, 1997).

This chapter takes a fresh approach to analysing the monetary policy performance in the sample of African economies, using the BVAR approach over the period 1980:01 to 2012:04. The main objective of this chapter is to analyse how monetary policy changed its behaviour in response to changes in information from a set of macroeconomic variables. This chapter considers as its theoretical background the study of Amano's (2007) which was discussed in Chapter 2, under the theoretical framework in the literature review and it is based on the assumption that the uncertainty in monetary policy arises from inflation persistence. This approach has been extended in this chapter to account for the prior belief of monetary policy on a set of macroeconomic variables and not just inflation

persistence alone.¹

The outline of the chapter is as follows. Following the introduction, section 7.2 discusses data and methodology. Section 7.3 focuses on the Gibbs sampler as a method for analysing the marginal conditional posterior distribution of the empirical BVAR model. This is used to evaluate the conditional distribution of the parameters of interest from the monetary policy model. Section 7.4 of the chapter is devoted to documenting prior specification and estimation of the empirical Bayesian methodology using an informative prior which is based on the assumption of a normal distribution. This is followed by analysis and discussion of the empirical results in section 7.5 and the impulse responses in section 7.6. Finally, section 7.7 concludes the chapter.

7.2 Data and Methodology

In order to formally introduce the Bayesian methodology, the empirical model is defined as the following VAR(p) process:

$$z_t = \phi_c^0 + \sum_{j=1}^p \phi_j z_{t-j} + \varepsilon_t \quad (7.1)$$

where, z_t is an $k \times 1$ vector, for $t = 1 \cdots T$ observations of endogenous variables², containing the output gap, inflation, the money supply, interest rate, a commodity price index, and the exchange rate. The selection of macroeconomic variables are included in the reduced form VAR as potential indicators for evaluating the transmission mechanism of monetary policy. They are also standard NKM variables for the monetary policy transmission mechanism. ϕ_c^0 is a $k \times 1$ vector of constants, ϕ_j is a $k \times k$ matrix of regression coefficients for the j^{th} lag with p being the maximum lag length, which is determined by the information criteria. We make a distributional assumption that ε_t (which is the $k \times 1$ vector of residual error terms) is independently, identically and multivariate normally distributed: $\varepsilon_t \sim i.i.d_{MN}(0, \Sigma)$ with mean zero and variance-covariance matrix, sigma (Σ). This classical regression assumption is used to characterise the conditional distribution of the data (z_t) given its history. Throughout this chapter, we shall refer to this process as Bayesian updating of the parameters, conditional

¹Carriero et al (2009) have used the Bayesian estimation framework for forecasting exchange rates, while Canova and Ciccarelli (2004) have used the Minnesota Prior for Bayesian Panel VAR.

²The variables are specified in levels which follows the Sims et al (1990) argument that the likelihood function of the posterior distribution in Bayesian inference has the same Gaussian shape, whether or not the variables are non-stationary.

on the set of macroeconomic variables. But first, the Bayesian estimation procedure is introduced in section 7.2.1 in order to shed some light on the empirical methodology.

7.2.1 The Bayesian Estimation Framework

Following the standard approach in the literature as in: Doan et al (1984), Litterman (1984, 1986), Kadiyala and Karlsson (1997), Robertson and Tallman (1999), Ciccarelli and Rebucci (2003), De Mol et al (2008) and Banbura et al (2010), we rewrite equation (7.1) as a multivariate VAR model in compact form as:

$$z_t = X_t \phi + \varepsilon_t \quad (7.2)$$

where for notational convenience, $X_t = (I_m \otimes Y_{t-1})$ is a $m \times mk$ vector with I_m being the identity matrix, while $Y_{t-1} = [z_{t-1}, z_{t-2}, \dots, z_{t-p}, 1]'$ is the $k \times 1$ vector of the set of macroeconomic variables, described above. $\phi = [\phi, \phi_1, \phi_2, \dots, \phi_p]'$ is the vector ($mk \times 1$) containing the coefficients representing the parameters of interest.

By implication, ϕ and Σ are the unknown parameters of the model, representing the information contained in the data. The VAR model in (7.1) is estimated by introducing the probability density function of the data $p(z_t)$, conditional on the joint prior probability of the parameters, $p(\phi, \Sigma)$ which represents the prior belief of the central bank. This follows Lutkepohl's (2005, p.237) analysis that the prior information in Bayesian analysis is expressed in terms of a probability density function due to the fact that all variables are treated as random parameters. In particular, this arises from the process of updating information, based on prior beliefs and uncertainty about the state of the economy. The estimation procedure assumes that the priors for the parameters ϕ and Σ belongs to a distributional family $p(\phi, \Sigma \mid \lambda_i)$ where, λ_i for $i = 1 \dots j$ is a vector of hyper-parameters³ and are based on the prior beliefs of the central bank about the distribution of shocks to the economy. This means the prior is the probability distribution of the central bank's level of uncertainty. It follows that the likelihood (multivariate normal likelihood) function for obtaining the data, given the information (which is represented by the parameters ϕ and Σ) is defined as:

$$L_{MN}(z_t \mid \phi, \Sigma) \propto \frac{1}{|\Sigma|^{T/2}} \exp \left\{ -\frac{1}{2} \sum_{t=1}^T (z_t - X_t \phi)' \Sigma^{-1} (z_t - X_t \phi) \right\} \quad (7.3)$$

³See section 7.4.

where \propto stands for proportional to, $L_{MN}(z_t \mid \phi, \Sigma)$ is the probability density function of the likelihood, while Σ^{-1} denotes the inverse of the variance-covariance matrix which is estimated using the Gibbs sampler for the medium size model containing five macroeconomic variables, given that the covariance matrices must be inverted. The Gibbs sampler is discussed in section 7.3, in order to maintain consistency in the flow of the argument. It follows from the likelihood function that the joint prior distribution of the parameters, conditional on the data is obtained through Bayes' rule and it is expressed below.

$$p(\phi, \Sigma \mid z_t) = \frac{p(\phi, \Sigma)L(z_t \mid \phi, \Sigma)}{p(z_t)} \quad (7.4)$$

The expression $p(\phi, \Sigma \mid z_t)$ is the posterior probability⁴ of obtaining the parameters given the data, where, $p(z_t)$ is assumed to be a randomized constant which is equal to one (Lutkepohl, 2005). That is $p(z_t)$ is an unconditional density (marginal probability) of observing the data z_t under all admissible outcomes. By implication, the joint posterior distribution of the parameters and the data is defined as the likelihood multiplied by the prior probability distribution of the parameters. Note that priors are set due to incomplete information, hence the process of Bayesian updating occurs when new information is received by the central banks. This is to say that the posterior distribution is.

$$p(\phi, \Sigma, z_t) = L(z_t \mid \phi, \Sigma)p(\phi, \Sigma)$$

It is important to evaluate the marginal posterior distribution of the parameters in equation (7.4) conditional on the data.⁵ These are the probability distributions of the vector of coefficients, $p(\phi \mid z_t)$ and the covariance matrix, $p(\Sigma \mid z_t)$ can be achieved by integrating each term (ϕ and Σ) from the Bayes' rule equation. One possible limitation to this approach is that integration of the full Bayesian estimation in equation (7.2) may be very complicated and perhaps produce inconsistent estimates of the marginal probabilities. In order to address this pitfall, we have used the Gibbs sampler⁶ to numerically integrate the posterior distributions from equation (7.4). This is the most frequently used method in the literature to derive the marginal posterior distribution of the parameters of interest. Respective draws of the posterior distribution ϕ and Σ are obtained using the Gibbs algorithm.

⁴This is the joint density of the model and it contains all the information available on the parameter vector, ϕ and Σ conditional on the data.

⁵This is because Bayesian analysis seeks to answer the question, what is the likelihood of the model given the data?

⁶This is also known as the independent Normal-Wishart prior (Koop and Korobilis, 2010).

7.3 Evaluating the Posterior Distribution: The Gibbs Sampler

The Gibbs sampler⁷ has been used in the literature to derive analytical integration of the conditional posterior distribution in equation (7.4). This is because in Bayesian analysis, the posterior is specified as a collection of conditional distributions (Lutkepohl, 2005). The advantages of this method is that it is not affected by model size and it produces reliable estimates of predicting shocks to the economy (Kadiyala and Karlsson, 1997). The Gibbs algorithm for BVAR treats the model as a system, rather than univariate equation-by-equation. This is based on a Markov Chain Monte Carlo (MCMC) algorithm for generating the posterior distributions of the impulse responses by sampling each variable from the conditional distribution and updating the variable with a new value. This recursive procedure is plausible because it requires only knowledge of the full conditional posterior distributions which are: $p(\phi \mid z_t)$ and $p(\Sigma \mid z_t)$. This section closely follows the approach by Gelfand et al (1990), Gelman et al (1995), Kadiyala and Karlsson (1997), Ciccarelli and Rebucci (2001) and Auer (2010) who have used the Gibbs sampling to evaluate estimates of the full Bayesian estimation of equation (7.2) conditional on the joint marginal posterior distribution of the parameters and the data. It begins with some initial values and samples each variable from the conditional distribution.

In order to describe this Markov Chain procedure, let ϕ_{iv}^0 denote the initial values of the coefficient parameters while Σ_{iv}^0 connotes the initial covariance matrix of the parameters, drawn from the marginal distribution of the values of other elements sampled in the previous iteration, while ignoring the rest of the sample. This is the so-called burn-in-draw which ignores some numbers of samples at the beginning of the MCMC process. In what follows, the new values $(\phi^{(m)}, \Sigma^{(m)})$ are obtained from (\sim) the initial values which are randomly determined from the marginal conditional distribution. This recursive MCMC procedure takes the following form:

$$\phi^{(m)} \sim p(\phi \mid \Sigma^{(m-1)}, z_t), \text{ for } m = 1, \dots, n$$

$$\Sigma^{(m)} \sim p(\Sigma \mid \phi^{(m)}, z_t)$$

The vector: $\zeta^{(m)} = [\phi^{(m)}, \Sigma^{(m)}]'$ forms a Markov Chain. In the empirical procedure, we have employed a large number of iterations (up to 2500 keeper draws) so

⁷This was introduced by the Physicist Gibbs and it is commonly used in statistics with applications to Bayesian inference for evaluating the posterior distribution.

that the MCMC forms the true joint distribution of the parameters in the model for the sample of African economies. This is important because any marginal density or posterior moment of interest can consistently be estimated with its corresponding sample average. The number of burn-in-draw (*nburns*) is set to 500 which is used to allow for corrections in the samples at the beginning of the Markov Chain procedure. However, the assumption about the prior type is required in order to consistently estimate the Gibbs sampler. This is discussed in section 7.4 below.

7.4 Prior Specification and Estimation

Different types of evaluation techniques have been proposed in the literature in order to estimate the joint prior distribution of the parameters in equation (7.2). These include: the Litterman prior, the normal-inverted Wishart prior⁸ and the Sims-Zha (1998) type priors (which are the normal-Wishart and normal-flat priors). The used of priors is to ensure that predictive standard errors can be estimated with consistency. Ciccarelli and Rebucci (2003) and Giannone et al (2012) suggest that choosing the prior is the key part of Bayesian inference. This is because of the specific economic problem being investigated as well as the assumption about the sample distribution: the random walk (as is the case with the Litterman prior. The tightness, which is also referred to as the degree of shrinkage is the level of confidence that is attributed to the central bank's prior distributional assumption, conditional on the information contained in the data (Auer, 2014). The uncertainty in monetary policy is captured by hyper-parameters, which represents the general belief about the series of macroeconomic variables in the model. This section focuses on the Minnesota prior which is the most commonly used prior in Bayesian estimation, originally developed by Litterman (1980, 1986) and Doan et al (1984). This is based on the assumption of a normal likelihood of the posterior distribution.

7.4.1 The Minnesota/Litterman Prior

Consider in equation (7.2) the prior probability of estimating a $k \times 1$ vector ϕ_j containing parameters of the j^{th} equation from the i^{th} system and with known variance of the residual term as $\sigma_j^2 \varepsilon_t$. Employing a similar framework from equation (7.2) suggests that the j^{th} observation is expressed as: $z_j = X_j \phi_j + \varepsilon_j$, $j = 1 \cdots T$ and ε_j is *i.i.d.* The Minnesota prior is based on the following assumptions. Firstly, it assumes that the residual variance-covariance matrix, Σ is fixed and diago-

⁸See Kadiyala and Karlsson (1997), Robertson and Tallman (1999) and Banbura et al (2010)

nal ($\Sigma \otimes \sigma_j^2 \varepsilon_t I_m$). Secondly, there is prior and posterior independence between equations, which implies that equations are estimated separately based on the assumption that the variance-covariance is diagonal (Karlsson, 2012). Thirdly, it also implies a univariate random walk behaviour⁹ for z_j . This implies that the prior means ($\bar{\phi}_j$) are specified as a random walk, where $\bar{\phi}_j$ is a point estimator of ϕ_j ¹⁰ and the residual variance is specified in terms of hyper-parameters in the structure of the diagonal elements of \bar{v}_j^ϕ (see Lutkepohl, 2005.p.233, who assumed a diagonal prior covariance matrix of residual elements). This is an initial assumption, which implies that the first lag mean is set to zero ($\bar{\phi}_j = 0$) to avoid overfitting of the model. This is the tendency for most elements to have prior means of coefficients which are equal to zero (Lutkepohl, 2005).

Following Litterman (1986), the prior distribution of ϕ_j and the likelihood becomes:

$$p(\phi_j) = N(\bar{\phi}_j, \bar{v}_j^\phi)$$

$$L(z_j | \phi_j, \sigma_j^2 \varepsilon_t) \propto |\sigma_j^2 \varepsilon_t|^{-T/2} \exp \left\{ -\frac{1}{2\sigma_j^2 \varepsilon_t} (z_j - X_j \phi_j)' (z_j - X_j \phi_j) \right\}$$

The Minnesota likelihood function is normal and is based on the assumption that the residual variances are known (Karlsson, 2012 and Davoodi et al, 2013). The posterior distribution of the parameters, conditional on the data has the following expression:

$$p(\phi_j | z_j) = p(\phi_j) L(z_j | \phi_j, \sigma_j^2 \varepsilon_t)$$

In assigning numerical values to the hyper-parameters: $\lambda_1, \dots, \lambda_n$ for $n = 1, \dots, 3$, Litterman (1986) assumed that the variance of the prior distribution of variable j in equation i for coefficients on the lag operator p is defined as:

$$var_{Litterman}(\phi_{i,j})^p = \begin{cases} \frac{\lambda_1}{p}, & i = j \\ \frac{\lambda_2}{p} \frac{\sigma_i^2}{\sigma_j^2}, & i \neq j \\ \lambda_3 \sigma_i^2 & c \end{cases} \quad (7.5)$$

where, λ_1 measures the overall tightness of the variance of first lag of the model. This is the degree of uncertainty of the variance for parameters of own lags. If λ_1 is too small say 0.01, it implies that the prior information (the belief of the

⁹Banbura et al (2010) argue this assumption to be plausible since most macroeconomic variables are characterized by mean deviations. This is to say that the Minnesota prior was originally developed for nonstationary series (Lutkepohl, 2005).

¹⁰The rationale is that by assuming a diffuse prior (infinite dispersion) of the prior distribution around its mean variance $\bar{v}_j^{\phi-1} = 0$, then the posterior mean of ϕ_j becomes the OLS point estimator: $\bar{\phi}_j = (X_j' X_j)^{-1} X_j' z_j$. See Lutkepohl (2005)

central bank in this case) dominates the sample information which is contained in the data. Therefore, λ_1 controls the relative importance of the prior and sample information. If $\lambda_1 = 0$, the posterior is equal to the prior information which indicates no level of uncertainty. Finally, if $\lambda_1 = \infty$, the posterior expectation is equivalent to an unrestricted OLS estimate (See Lutkepohl, 2005). However, given that most of the African economies have implemented an inflation targeting framework, we consider a small degree of overall uncertainty in monetary policy prior belief about the distribution of shocks to the economy. This is to say that monetary policy has the capacity to anchor shocks from macroeconomic variables and will not incorporate a high degree of uncertainty in its monetary policy framework. Precisely, in the empirical procedure, we set $\lambda_1 = 0.1$ (which is a smaller tightness, corresponding to greater confidence) and check robustness against $\lambda_1 = 0.2$ which is used in the literature and found to yield plausible estimates of the posterior distribution of parameters and conditional on the set of macroeconomic variables (Gupta and Sichei, 2006).

λ_2 represents the relative tightness of the variance of other variables in the system. In the empirical application, we set $\lambda_2 = 0.5$ assuming a symmetric Minnesota prior where the relative uncertainty of other variables in the system are given equal probabilities against the baseline value of $\lambda_2 = 0.99$. Compared to λ_1 , more shrinkage is attributed to the variance of other variables to reinforce the univariate random walk assumption of the Minnesota prior. This is because if $\lambda_1 > \lambda_2$, own lags are more likely to be important predictors than the lags of other variables.¹¹ Note that if $\lambda_2 = 0$, the BVAR tends to a vector of univariate models and it renders estimation infeasible.¹² If λ_2 approaches one it implies that all coefficients of lag one have about the same prior variance with the exception of the ratio σ_i^2/σ_j^2 which is a scaling factor that controls for the variability in the data. The standard error of residual values from OLS are used to scale the precision with the prior mean set to 1 for own lags in each equation and 0 otherwise, following the Gibbs algorithm. The constant term, ϕ_c^0 has a mean of zero with zero precision. This implies that the intercept is an uninformative or diffuse prior (Kadiyala and Karlsson, 1997; Carriero et al, 2011).

Finally, $\lambda_3 > 0$ represents the relative tightness of the variance of the lags (which is also referred to as the lag decay), for parameters of deterministic variables such as the constant term and exogenous variables. Koop and Korobilis

¹¹The choice of the different scalars (or hyperparameters) requires some experimentation (Koop and Korobilis, 2010).

¹²This often produces a near-singular matrix error message when estimating the model.

(2010) assume that $\lambda_3 = 2$, while Kadiyala and Karlsson (1997) sets $\lambda_3 = 1$, assuming a linear decay function in the precision of the model. This shrinks all VAR coefficients to zero as the lag length increases. This allows us to consider the fact that increasing lag lengths provide more information on monetary policy. The assumption is reasonable and produces good forecast estimates of the variance of the shocks to the economy.

7.5 Empirical BVAR Results

Table 7.1 through 7.8 reports the BVAR estimates for the monetary policy interest rate equation, from the output gap, inflation, money supply, commodity price, interest rate and the exchange rate system for each of the African economies.¹³ These are derived from the Minnesota prior through mixed estimation with the assumption of a prior mean of zero for all coefficients and a linear decay ($\lambda_3 = 1$) in the precision of the model with the lag type defined as harmonic¹⁴ (Litterman, 1986; Lutkepohl, 2005). The constant term is unrestricted, which means it is uninformative, with prior variance set to infinity (as in Kadiyala and Karlsson, 1997 and Lutkepohl, 2005). λ_1 in the monetary policy equation measures the degree of uncertainty of the variance of coefficients of own lags as well as the overall prior variance of all VAR coefficients. The *F – statistics* represents the joint test in the interest rate equation, with probability values represented in square parentheses for the joint explanatality of the model. The coefficients of the monetary policy interest rate reduces as the lag length increases. In Algeria, Nigeria and Uganda, the coefficients of the first lag of the interest rate (i_{t-1}) which is the dependent variable in the system has prior variances which are close to zero. In Botswana, Ghana, Kenya, South Africa and Tunisia they are concentrated around zero for different prior variances. These results are consistent with the Minnesota assumption that prior mean have coefficients close to zero (Davoodi et al, 2013).

The results also reinforce the finding that the coefficients of high order lags are likely to be close to zero. In particular, λ_2 measures the relative tightness of the variance of coefficients of the lagged macroeconomic variables in the monetary policy interest rate equation is zero for the sample of African economies. Intuitively, this implies that the uncertainty in the prior variance of the mone-

¹³Coefficients for Bayesian analysis are estimated separately through mixed estimation given the Minnesota assumption of prior and posterior independence between equations (Lutkepohl, 2005 and Gupta and Sichei, 2006).

¹⁴This means that standard error of prior on lag p has a factor of $(p * -1.0)$. See Lutkepohl (2005)

tary policy interest rate decreases with increasing lag length. This explains why higher order lags provide more information to monetary policy makers in terms of capturing the uncertainty in macroeconomic variables. With two lags, the empirical Bayesian model has prior variance of the coefficients which are concentrated around zero, and it is consistent with the assumption of the Minnesota prior.

The implications of Bayesian shrinkage is reflected in Table 7.1 through to 7.8 by imposing different hyper-parameters for the tightness in the variance of monetary policy, in comparison with the unrestricted least squares VAR estimates where, $\lambda_1 = \infty$ and λ_2 is set to a conditional probability of one. The results reveal that for $\lambda_1 = 1.0$ and $\lambda_2 = 0.99$, the coefficients of interest are quite similar to the unrestricted VAR estimates for each of the African economies. These results suggests that the variance of monetary policy increases when monetary policy is accommodative by allowing high degree of uncertainty in its monetary policy framework. In particular, an accommodative monetary policy, by lowering the interest rate when shocks to the macroeconomic variables are persistent, results in policy ineffectiveness for the central bank due a to high degree of uncertainty that is not accounted for by the monetary authority. On the other hand, when monetary policy decreases the overall uncertainty to zero for the two combinations of prior types ($\lambda_1 = 0.01$, $\lambda_2 = 0.99$ and $\lambda_1 = 0.01$, $\lambda_2 = 0.5$) tightens the prior variance and shrinks all VAR coefficients to close to zero. The analysis of the results indicates that overfitting of the BVAR is solved by reducing the overall uncertainty in monetary policy in order to decrease the prior variance and decreasing the relative variance of other macroeconomic variables apart from the monetary policy interest rate, which shrinks coefficients towards zero. This is important because most of the sampled African economies are inflation targeting countries aimed at restricting inflation to a target level. By allowing a high degree of uncertainty in monetary policy, it may result in the central bank being unlikely to achieve its monetary policy objectives. These results are consistent with the study of Gupta and Sichei (2006) for the South African economy, who found that a tight prior produces better estimates for the transmission mechanism of the monetary policy shocks.

The policy implications suggests that monetary policy has stronger effects on the economy when the uncertainty of the central bank is reduced. The optimal hyper-parameters for the BVAR estimates of monetary policy for the sample of African economies is achieved where, $\lambda_1 = 0.1$ and $\lambda_2 = 0.5$. This is because the prior coefficients are close to zero which corresponds with the Minnesota principle of zero prior means. Comparing these results for the monetary policy

equation when $\lambda_2 = 0.5$ and $\lambda_2 = 0.99$, it can be established from the findings that the overall uncertainty in the monetary policy interest rate is affected when the variance of other macroeconomic variables is higher as compared to when it is smaller. The coefficients of the variance of the macroeconomic variables are closer to zero for combinations of hyper-parameters, $\lambda_1 = 0.1$, $\lambda_2 = 0.5$. This inference has been used to derive IRF of the BVAR in section 7.6, which represents estimates of the monetary policy transmission mechanism.

Table 7.1: Bayesian Estimates of Monetary Policy in Algeria

Table 7.1: Algeria Bayesian Estimates of the Monetary Policy Equation.

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	pc_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	pc_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	0.142 (0.154)	24.716** (10.527)	0.142** (0.066)	0.005 (0.009)	0.560** (0.083)	1.028 (1.398)	-23.024** (11.284)	-0.100 (0.065)	-0.002 (0.009)	0.339** (0.079)	4.204** (1.356)	518.905** [0.000]
1.0	.99	0.147 (0.148)	23.263** (9.810)	0.133** (0.060)	0.005 (0.009)	0.564** (0.079)	1.040 (1.334)	-21.344 (10.476)	-0.090 (0.060)	-0.002 (0.009)	0.333** (0.075)	4.074** (1.280)	564.000** [0.000]
0.01	.99	4.366** (0.324)	-1.6703 (3.312)	0.078** (0.016)	-0.001 (0.004)	0.147** (0.027)	0.207 (0.450)	-0.394 (1.823)	0.020** (0.009)	-0.000 (0.002)	0.036 (0.014)	0.064 (0.226)	19.859** [0.000]
0.1	.99	0.361** (0.151)	7.192 (4.934)	0.052** (0.025)	0.000 (0.006)	0.648** (0.043)	0.951 (0.999)	-2.884 (4.685)	0.006 (0.024)	-0.000 (0.005)	0.204** (0.037)	1.068 (0.646)	519.929** [0.000]
0.2	.99	0.213 (0.148)	11.754 (6.960)	0.066 (0.038)	0.003 (0.008)	0.627** (0.060)	1.090 (1.208)	-8.047 (7.041)	-0.019 (0.038)	-0.013 (0.007)	0.259** (0.056)	2.345** (0.963)	558.020** [0.000]
1.0	.50	0.151 (0.148)	20.091** (9.126)	0.112** (0.056)	0.005 (0.009)	0.564** (0.079)	1.093 (1.314)	-17.621 (9.646)	-0.071 (0.056)	-0.002 (0.009)	0.333** (0.075)	3.722** (1.220)	567.181** [0.000]
0.01	.50	4.852 (0.338)	-0.842 (2.011)	0.027** (0.009)	-0.000 (0.002)	0.166** (0.029)	0.064 (0.251)	-0.172 (1.035)	0.007 (0.005)	-0.000 (0.001)	0.041** (0.016)	0.019 (0.126)	21.448** [0.000]
0.1	.50	0.353 (0.151)	4.428 (3.164)	0.046** (0.016)	-0.000 (0.005)	0.660** (0.043)	0.471 (0.656)	-0.097 (2.682)	0.009 (0.014)	-0.000 (0.003)	0.203** (0.038)	0.346 (0.361)	554.113** [0.000]
0.2	.50	0.203 (0.150)	6.817 (4.872)	0.047 (0.025)	0.001 (0.006)	0.635** (0.061)	0.855 (0.987)	-2.233 (4.628)	-0.000 (0.024)	-0.000 (0.005)	0.259** (0.057)	1.017 (0.638)	568.223** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Results are obtained using the RATS software.

Table 7.2: Bayesian Estimates of Monetary Policy in Botswana

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	pc_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	pc_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	0.217 (0.369)	6.526 (4.971)	0.041 (0.047)	0.011 (0.008)	1.021** (0.092)	0.114 (0.200)	-2.454 (4.910)	-0.012 (0.048)	-0.014 (0.008)	-0.064 (0.092)	0.129 (0.196)	990.137** [0.000]
1.0	.99	0.221 (0.354)	6.492 (4.689)	0.041 (0.045)	0.011 (0.007)	1.012** (0.087)	0.114 (0.192)	-2.374 (4.627)	-0.012 (0.045)	-0.014 (0.007)	-0.054 (0.086)	0.125 (0.185)	1074.191** [0.000]
0.01	.99	9.212** (0.469)	0.340 (1.808)	-0.001 (0.017)	0.000 (0.003)	0.172** (0.030)	0.010 (0.072)	0.134 (0.931)	-0.000 (0.008)	0.002 (0.002)	0.041** (0.016)	0.003 (0.036)	21.222** [0.000]
0.1	.99	0.679** (0.338)	4.590 (2.655)	0.025 (0.026)	0.003 (0.005)	0.795** (0.043)	0.079 (0.146)	0.162 (2.303)	-0.002 (0.022)	-0.003 (0.004)	0.129** (0.040)	0.032 (0.095)	973.369** [0.000]
0.2	.99	0.339 (0.344)	5.712 (3.607)	0.035 (0.035)	0.007 (0.007)	0.891** (0.064)	0.104 (0.175)	-1.073 (3.442)	-0.007 (0.033)	-0.008 (0.006)	0.058 (0.062)	0.068 (0.142)	1049.031** [0.000]
1.0	.50	0.235 (0.351)	6.220 (4.480)	0.039 (0.043)	0.010 (0.008)	1.013 (0.087)	0.106 (0.189)	-2.108 (4.400)	-0.011 (0.045)	-0.012 (0.008)	-0.056 (0.086)	0.111 (0.177)	1076.001** [0.000]
0.01	.50	9.197** (0.439)	0.094 (0.940)	-0.000 (0.009)	0.000 (0.002)	0.171** (0.030)	0.003 (0.036)	0.036 (0.474)	-0.000 (0.005)	0.000 (0.000)	0.041** (0.016)	0.000 (0.018)	21.216** [0.000]
0.1	.50	0.749** (0.317)	3.342 (1.843)	0.016 (0.018)	0.002 (0.004)	0.798** (0.043)	0.033 (0.097)	0.510 (1.311)	0.000 (0.012)	-0.000 (0.002)	0.125** (0.040)	0.009 (0.018)	970.638** [0.000]
0.2	.50	0.407 (0.333)	4.413 (2.619)	0.024 (0.026)	0.003 (0.005)	0.896** (0.064)	0.057 (0.143)	-0.014 (2.269)	-0.002 (0.021)	-0.003 (0.004)	0.052 (0.063)	0.026 (0.094)	1047.105** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Table 7.3: Bayesian Estimates of Monetary Policy in Ghana

Table 7.3: Ghana Bayesian Estimates of the Monetary Policy Equation.

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	-0.206 (1.180)	-2.751 (4.790)	0.015 (0.020)	0.157 (0.139)	1.196** (0.090)	3.912 (4.516)	1.592 (4.787)	-0.020 (0.020)	0.009 (0.141)	-0.242** (0.090)	-4.274 (1.180)	869.910** [0.000]
1.0	.99	-0.248 (1.131)	-2.765 (4.478)	0.015 (0.019)	0.154 (0.132)	1.183** (0.085)	3.846 (4.115)	1.667 (4.418)	-0.020 (0.019)	0.016 (0.133)	-0.226** (0.085)	-4.200 (4.262)	944.283** [0.000]
0.01	.99	21.068** (1.373)	-0.342 (1.378)	-0.002 (0.006)	-0.000 (0.058)	0.171** (0.030)	-2.729** (0.978)	-0.007 (0.701)	-0.000 (0.003)	0.003 (0.029)	0.040** (0.016)	-0.743 (0.808)	21.349** [0.000]
0.1	.99	0.005 (1.103)	-1.552 (2.580)	0.008 (0.010)	0.132 (0.087)	0.840** (0.044)	1.271 (2.146)	1.199 (1.823)	-0.007 (0.008)	0.061 (0.073)	0.089** (0.042)	-1.625 (2.209)	835.053** [0.000]
0.2	.99	-0.604 (1.115)	-2.324 (3.366)	0.013 (0.013)	0.132 (0.109)	0.986** (0.063)	2.655 (3.135)	1.933 (2.890)	-0.013 (0.012)	0.062 (0.104)	-0.035 (0.062)	-2.928 (3.242)	917.443** [0.000]
1.0	.50	-0.265 (1.127)	-2.727 (4.196)	0.013 (0.017)	0.154 (0.128)	1.182** (0.085)	3.484 (3.924)	1.798 (4.004)	-0.018 (0.017)	0.014 (0.128)	-0.227** (0.085)	-3.819 (4.064)	950.563** [0.000]
0.01	.50	20.113 (1.182)	-0.085 (0.711)	-0.000 (0.003)	0.002 (0.029)	0.178** (0.030)	-1.952** (0.639)	-0.018 (0.357)	-0.000 (0.002)	0.001 (0.015)	0.042** (0.016)	-0.495 (0.422)	23.039** [0.000]
0.1	.50	0.472 (1.004)	-0.509 (1.715)	0.005 (0.007)	0.112 (0.062)	0.844** (0.045)	0.214 (1.219)	0.448 (1.040)	-0.002 (0.005)	0.035 (0.043)	0.084 (0.041)	-0.585 (1.237)	858.542** [0.000]
0.2	.50	-0.544 (1.069)	-0.999 (2.477)	0.009 (0.009)	0.136 (0.083)	0.997** (0.063)	1.110 (2.060)	1.184 (1.754)	-0.006 (0.008)	0.041 (0.070)	-0.043 (0.062)	-1.318 (2.125)	947.795** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Table 7.4: Bayesian Estimates of Monetary Policy in Kenya

Table 7.4: Kenya Bayesian Estimates of the Monetary Policy Equation.

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	0.308 (0.330)	0.300 (3.180)	-0.010 (0.021)	0.039 (0.077)	1.271** (0.089)	-0.149 (1.145)	2.079 (3.319)	0.019 (0.020)	0.080 (0.080)	-0.409** (0.087)	0.048 (1.135)	318.914** [0.000]
1.0	.99	0.306 (0.317)	0.539 (2.937)	-0.009 (0.019)	0.036 (0.073)	1.250** (0.085)	-0.060 (1.072)	1.889 (3.034)	0.018 (0.019)	0.084 (0.076)	-0.388** (0.082)	-0.040 (1.063)	346.957** [0.000]
0.01	.99	3.032 (0.747)	-0.460 (0.735)	0.008 (0.005)	0.039 (0.025)	0.107** (0.026)	-0.039 (0.207)	-0.055 (0.376)	0.002 (0.003)	0.012 (0.013)	0.023 (0.014)	-0.046 (0.152)	10.315** [0.000]
0.1	.99	0.404 (0.351)	2.191 (1.566)	0.010 (0.010)	0.067 (0.045)	0.795** (0.049)	0.356 (0.520)	0.923 (1.203)	0.003 (0.008)	0.077 (0.040)	0.020 (0.043)	-0.483 (0.512)	280.684** [0.000]
0.2	.99	0.309 (0.327)	2.058 (2.033)	0.003 (0.013)	0.032 (0.058)	0.996** (0.064)	0.463 (0.767)	1.052 (1.835)	0.006 (0.012)	0.099 (0.058)	-0.142** (0.060)	-0.578 (0.758)	332.133** [0.000]
1.0	.50	0.303 (0.317)	0.871 (2.678)	-0.005 (0.018)	0.042 (0.069)	1.253** (0.084)	-0.062 (1.006)	1.449 (2.696)	0.015 (0.017)	0.077 (0.072)	-0.391** (0.082)	-0.038 (0.997)	353.843** [0.000]
0.01	.50	3.096 (0.607)	-0.132 (0.392)	0.002 (0.003)	0.011 (0.014)	0.110** (0.027)	-0.027 (0.138)	-0.017 (0.197)	0.000 (0.001)	0.003 (0.007)	0.024 (0.014)	-0.016 (0.082)	10.475** [0.000]
0.1	.50	0.500 (1.443)	1.601 (1.066)	0.008 (0.007)	0.083** (0.032)	0.818** (0.048)	0.053 (0.291)	0.556 (0.678)	0.001 (0.005)	0.038 (0.023)	0.012 (0.043)	-0.176 (0.282)	315.136** [0.000]
0.2	.50	0.330 (0.323)	1.957 (1.455)	0.006 (0.009)	0.069 (0.042)	1.019 (0.062)	0.139 (0.484)	0.709 (1.117)	0.002 (0.008)	0.054 (0.038)	-0.156 (0.060)	-0.250 (0.476)	363.266** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation
 ** indicates significance at the 5% level, (.) = standard errors.

Table 7.5: Bayesian Estimates of Monetary Policy in Nigeria

Table 7.5: Nigeria Bayesian Estimates of the Monetary Policy Equation.

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	3.695** (1.570)	-1.874 (4.161)	-0.008 (0.032)	-0.013 (0.239)	0.983** (0.115)	0.609 (1.399)	1.734 (3.890)	0.014 (0.032)	0.106 (0.224)	-0.147 (0.113)	-0.957 (1.383)	135.131** [0.000]
1.0	.99	3.715** (1.480)	-1.709 (3.852)	-0.008 (0.029)	-0.010 (0.222)	0.967** (0.106)	0.622 (1.279)	1.610 (3.579)	0.013 (0.029)	0.100 (0.207)	-0.131 (0.103)	-0.973 (1.264)	151.350** [0.000]
0.01	.99	16.079** (1.152)	0.006 (0.743)	0.004 (0.007)	0.004 (0.042)	0.040 (0.020)	-0.474** (0.213)	0.004 (0.376)	0.001 (0.003)	0.001 (0.021)	0.009 (0.010)	-0.130 (0.120)	2.263 [0.109]
0.1	.99	6.292** (1.478)	0.040 (2.282)	0.004 (0.017)	0.037 (0.146)	0.632** (0.057)	-0.083 (0.552)	0.189 (1.628)	0.002 (0.015)	0.032 (0.095)	0.085 (0.045)	-0.472 (0.521)	111.911** [0.000]
0.2	.99	4.340** (1.470)	-0.376 (2.951)	0.000 (0.023)	0.020 (0.182)	0.789** (0.076)	0.372 (0.840)	0.563 (2.467)	0.005 (0.021)	0.053 (0.144)	0.020 (0.069)	-0.781 (0.820)	141.479** [0.000]
1.0	.50	3.729** (0.477)	-1.513 (3.657)	-0.006 (0.028)	-0.007 (0.213)	0.969** (0.105)	0.485 (1.182)	1.404 (3.333)	0.011 (0.028)	0.092 (0.194)	-0.133 (0.103)	-0.839 (1.167)	152.573** [0.000]
0.01	.50	14.418** (0.820)	0.001 (0.394)	0.002 (0.004)	0.001 (0.022)	0.042 (0.021)	-0.168 (0.125)	0.001 (0.198)	0.000 (0.002)	0.000 (0.011)	0.009 (0.010)	-0.045 (0.064)	2.334 [0.102]
0.1	.50	6.179** (1.404)	0.132 (1.530)	0.004 (0.011)	0.021 (0.094)	0.637** (0.056)	-0.324 (0.328)	0.069 (0.907)	0.001 (0.008)	0.011 (0.052)	0.085 (0.045)	-0.212 (0.283)	114.656** [0.000]
0.2	.50	4.345** (1.443)	-0.030 (2.172)	0.002 (0.016)	0.025 (0.139)	0.797** (0.075)	-0.073 (0.527)	0.217 (1.552)	0.002 (0.014)	0.024 (0.090)	0.017 (0.069)	-0.340 (0.498)	144.068** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Table 7.6: Bayesian Estimates of Monetary Policy in South Africa

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	0.130 (0.410)	50.170** (15.070)	0.007 (0.073)	-0.014 (0.180)	1.217** (0.089)	0.172 (0.149)	-43.193** (14.452)	0.016 (0.072)	0.139 (0.189)	-0.284** (0.088)	0.009 (0.151)	659.072** [0.000]
1.0	.99	0.131 (0.393)	49.646** (14.248)	0.008 (0.069)	-0.002 (0.170)	1.200** (0.083)	0.170 (0.142)	-42.087** (13.631)	0.014 (0.068)	0.130 (0.179)	-0.267** (0.082)	0.012 (0.143)	713.743** [0.000]
0.01	.99	9.475** (0.598)	5.450 (5.288)	0.044 (0.024)	0.062 (0.069)	0.138** (0.028)	0.004 (0.053)	1.486 (2.729)	0.009 (0.012)	0.020 (0.038)	0.031** (0.015)	0.001 (0.026)	15.066** [0.000]
0.1	.99	0.483 (0.420)	27.808** (9.079)	0.033 (0.039)	0.163 (0.108)	0.808** (0.046)	0.102 (0.120)	-8.511 (7.475)	-0.002 (0.034)	0.033 (0.100)	0.068 (0.041)	0.019 (0.079)	535.040** [0.000]
0.2	.99	0.198 (0.402)	39.443** (11.549)	0.026 (0.053)	0.116 (0.138)	0.980** (0.063)	0.144 (0.136)	-24.847** (10.533)	-0.004 (0.050)	0.046 (0.140)	-0.065 (0.060)	0.025 (0.111)	647.008** [0.000]
1.0	.50	0.147 (0.393)	45.952** (13.724)	0.009 (0.065)	0.017 (0.163)	1.202** (0.083)	0.166 (0.140)	-38.155** (13.00)	0.013 (0.064)	0.112 (0.171)	-0.271** (0.082)	0.010 (0.137)	713.519** [0.000]
0.01	.50	10.000** (0.534)	1.601 (2.833)	0.013 (0.013)	0.019 (0.039)	0.141** (0.029)	0.001 (0.027)	0.432 (1.429)	0.002 (0.007)	0.006 (0.019)	0.032** (0.015)	0.000 (0.014)	15.120** [0.000]
0.1	.50	0.525 (0.403)	16.965** (6.320)	0.024 (0.026)	0.158** (0.075)	0.818** (0.047)	0.047 (0.080)	-0.768 (4.319)	0.002 (0.020)	0.036 (0.058)	0.060 (0.042)	0.007 (0.044)	545.272** [0.000]
0.2	.50	0.245 (0.399)	23.689** (8.682)	0.019 (0.037)	0.145 (0.102)	0.991** (0.064)	0.099 (0.113)	-9.323 (7.088)	0.000 (0.033)	0.029 (0.095)	-0.080 (0.061)	0.011 (0.074)	635.211** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Table 7.7: Bayesian Estimates of Monetary Policy in Tunisia

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	0.264 (0.135)	0.008 (0.006)	0.006 (0.008)	-0.005 (0.013)	1.377** (0.104)	-0.247 (0.143)	0.000 (0.006)	0.011 (0.009)	0.008 (0.012)	-0.469** (0.095)	0.133 (0.153)	416.243** [0.000]
1.0	.99	0.272** (0.127)	0.008 (0.005)	0.007 (0.007)	-0.007 (0.012)	1.350** (0.096)	-0.248 (0.130)	0.000 (0.005)	0.011 (0.008)	0.009 (0.010)	-0.440** (0.087)	0.132 (0.140)	471.986** [0.000]
0.01	.99	1.518** (0.117)	0.000 (0.002)	0.006** (0.003)	-0.004 (0.004)	0.420** (0.028)	-0.340** (0.043)	0.000 (0.001)	0.002 (0.001)	-0.001 (0.002)	0.102** (0.018)	-0.084** (0.024)	167.326** [0.000]
0.1	.99	0.472** (0.129)	0.008 (0.004)	0.017** (0.004)	-0.011 (0.007)	0.829** (0.051)	-0.197** (0.069)	0.000 (0.003)	0.007 (0.003)	0.008 (0.006)	0.027 (0.044)	0.003 (0.064)	452.903** [0.000]
0.2	.99	0.366** (0.128)	0.010** (0.005)	0.013** (0.006)	-0.014 (0.009)	1.032** (0.069)	-0.224** (0.092)	-0.000 (0.004)	0.010 (0.006)	0.014 (0.008)	-0.152** (0.062)	0.069 (0.094)	479.069** [0.000]
1.0	.50	0.269** (0.125)	0.009 (0.005)	0.007 (0.007)	-0.006 (0.011)	1.357** (0.094)	-0.227 (0.120)	0.000 (0.005)	0.010 (0.008)	0.008 (0.010)	-0.449 (0.086)	0.111 (0.128)	493.870** [0.000]
0.01	.50	0.876** (0.087)	-0.000 (0.001)	0.002 (0.002)	-0.000 (0.003)	0.501** (0.029)	-0.114** (0.028)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.001)	0.121** (0.019)	-0.028 (0.014)	229.480** [0.000]
0.1	.50	0.318** (0.114)	0.003 (0.003)	0.011** (0.003)	-0.002 (0.005)	0.887** (0.050)	-0.121** (0.047)	0.000 (0.002)	0.003 (0.002)	0.003 (0.003)	0.016 (0.045)	-0.012 (0.036)	665.330** [0.000]
0.2	.50	0.298** (0.118)	0.006 (0.004)	0.013** (0.004)	-0.005 (0.007)	1.087** (0.067)	-0.143** (0.062)	0.000 (0.002)	0.005 (0.003)	0.006 (0.005)	-0.185** (0.061)	0.014 (0.057)	601.397** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

Table 7.8: Bayesian Estimates of Monetary Policy in Uganda

λ_1	λ_2	constant	y_{t-1}	π_{t-1}	m_{t-1}	i_{t-1}	er_{t-1}	y_{t-2}	π_{t-2}	m_{t-2}	i_{t-2}	er_{t-2}	$F - test$
∞	1	1.968 (1.742)	-13.765** (5.561)	-0.032 (0.023)	0.206 (0.216)	0.995** (0.094)	-2.479 (2.111)	6.144 (5.298)	0.048** (0.019)	-0.168 (0.238)	-0.095 (0.092)	2.404 (2.094)	347.469** [0.000]
1.0	.99	1.996 (1.662)	-13.438** (5.263)	-0.029 (0.021)	0.200 (0.203)	0.980** (0.089)	-2.389 (1.968)	5.587 (4.967)	0.045** (0.017)	-0.161 (0.223)	-0.081 (0.086)	2.309 (1.951)	381.738** [0.000]
0.01	.99	17.438** (2.904)	-0.544 (1.535)	0.005 (0.005)	0.196** (0.056)	0.100** (0.025)	-0.083 (0.391)	-0.125 (0.772)	0.001 (0.002)	0.058 (0.034)	0.024 (0.013)	-0.052 (0.266)	10.113** [0.000]
0.1	.99	2.546 (1.630)	-7.522 (3.787)	0.002 (0.011)	0.087 (0.109)	0.713** (0.047)	-0.355 (0.885)	-0.557 (2.484)	0.009 (0.008)	0.009 (0.105)	0.122** (0.040)	0.320 (0.861)	361.903** [0.000]
0.2	.99	2.317 (1.624)	-10.268** (4.589)	-0.008 (0.015)	0.116 (0.153)	0.823** (0.066)	-1.171 (1.366)	0.964 (3.673)	0.020 (0.012)	-0.060 (0.160)	0.060 (0.061)	1.074 (1.344)	390.745** [0.000]
1.0	.50	2.012 (1.648)	-12.603** (5.115)	-0.025 (0.020)	0.183 (0.192)	0.974** (0.088)	-2.205 (1.838)	4.564 (4.699)	0.039** (0.016)	-0.143 (0.210)	-0.074 (0.086)	2.121 (1.820)	389.315** [0.000]
0.01	.50	20.073** (2.211)	-0.145 (0.826)	0.002 (0.002)	0.078** (0.035)	0.120** (0.026)	-0.219 (0.257)	-0.032 (0.413)	0.000 (0.001)	0.021 (0.018)	0.026 (0.014)	-0.066 (0.148)	10.834** [0.000]
0.1	.50	2.393 (1.582)	-3.400 (2.519)	0.004 (0.007)	0.080 (0.070)	0.721** (0.048)	-0.112 (0.502)	-0.316 (1.402)	0.004 (0.004)	0.017 (0.059)	0.122** (0.040)	0.079 (0.473)	378.994** [0.000]
0.2	.50	2.185 (1.587)	-6.627 (3.700)	0.001 (0.011)	0.078 (0.107)	0.823** (0.066)	-0.516 (0.868)	-0.050 (2.434)	0.008 (0.008)	-0.019 (0.103)	0.064 (0.062)	0.425 (0.844)	408.253** [0.000]

Note: Estimates are based on Minnesota prior with prior mean of 0 and a lag decay of 1. Estimation by mixed estimation

** indicates significance at the 5% level, (.) = standard errors.

7.6 Impulse Responses of the BVAR to a one SD Interest Rate Shock

The estimates of the BVAR impulse responses are reported in Figures 7.1 to 7.3 following a positive shock to the monetary policy interest rate. The confidence intervals represent 0.16 and 0.84 percentiles of the empirical posterior distribution of the IRF and are derived from the Gibbs algorithm by Monte Carlo simulations over 24 quarters of the forecast horizon. This is represented on the horizontal axis, while the vertical axis represents the magnitude of the shock to the variables. Following Giannone et al (2012), this means that the IRF are forecast graphs of the dynamic response of monetary policy to shocks from the macroeconomic variables. The results on real domestic variables which are the output gap, inflation and the money supply are consistent with evidence from the literature that a contractionary monetary policy shock that increases the short-term interest rate is followed by a fall in the output gap, inflation and the money supply for the period contemporaneous to the shock from monetary policy.

In particular, an exogenous shock to the interest rate leads to highly significant reduction in the output gap in the sample of African economies. One exception is Tunisia where the output gap falls gradually and reaches its peak after 4 quarters contemporaneous to the shock to monetary policy. The results indicate a strong initial response of the output gap below zero in Botswana, Ghana and Kenya following an interest rate shock but eventually returning to its long-run equilibrium level after 15 quarters in Botswana and Kenya and 6 quarters on average for Ghana. The response of the output gap fall is mild in Algeria and Nigeria. For South Africa and Uganda, the output gap falls immediately below zero from the contemporaneous period to the shock to monetary policy.

A rise in interest rate induces a fall in inflation along with its determinants set such as commodity prices for Algeria and Botswana. Inflation falls in Botswana, Ghana, Kenya, Nigeria and Uganda following the shock to monetary policy. The estimation for South Africa shows a very small increase in inflation up to 11 quarters after the shock to monetary policy. This result is consistent with evidence from the literature that following a contractionary monetary policy, inflation declines and prices are sticky with a delayed impact of at least 6 quarters after the shock to monetary policy (Rafiq and Mallick, 2008). For Algeria and Tunisia, the impact of inflation is mild, although inflation persists from the period following the shock to monetary policy. This may be due to the fact that both Algeria and Tunisia are non-inflation targeting emerging economies within the sample of the

African economies considered.

These results are consistent with evidence from the literature that in the absence of a liquidity puzzle, a positive monetary policy shock is manifested by a fall in the money supply. For Ghana, Kenya, South Africa, Tunisia and Uganda, the money supply is insignificant and falls below zero following the shock from monetary policy. For Nigeria, the money supply persists after the contemporaneous period following the shock to monetary policy. This may have resulted from the changes in the monetary policy framework in Nigeria, from monetary targeting to an inflation targeting framework which was introduced by the CBN in 2007 and which affected the transmission mechanism of monetary policy.

A positive monetary policy shock increases the interest rate for the sample of African economies. There is a strong interest rate response for Algeria, Ghana and Botswana from the shock to monetary policy. However, the monetary policy shock in Kenya and Nigeria is manifested by a gradual lowering of the interest rate. For Kenya, this is potentially due to the change in the monetary policy framework from monetary targeting to interest rate setting which was introduced by the CBK in 2008. For Nigeria, the results correspond with the changes in the monetary policy framework during the post liberalization period which was characterized by the introduction of SAP and macroeconomic reforms. Similar results are derived from the SVAR methodology which was used in Chapter 5.

Finally, the exchange rate is positive in Algeria, Botswana, Ghana, Kenya, Nigeria and Uganda following an interest rate shock. A positive monetary policy shock is seen to induce a gradual appreciation of the exchange rate in South Africa and Tunisia. The response is more delayed in Tunisia and less pronounced in South Africa after the periods following the shock to monetary policy.

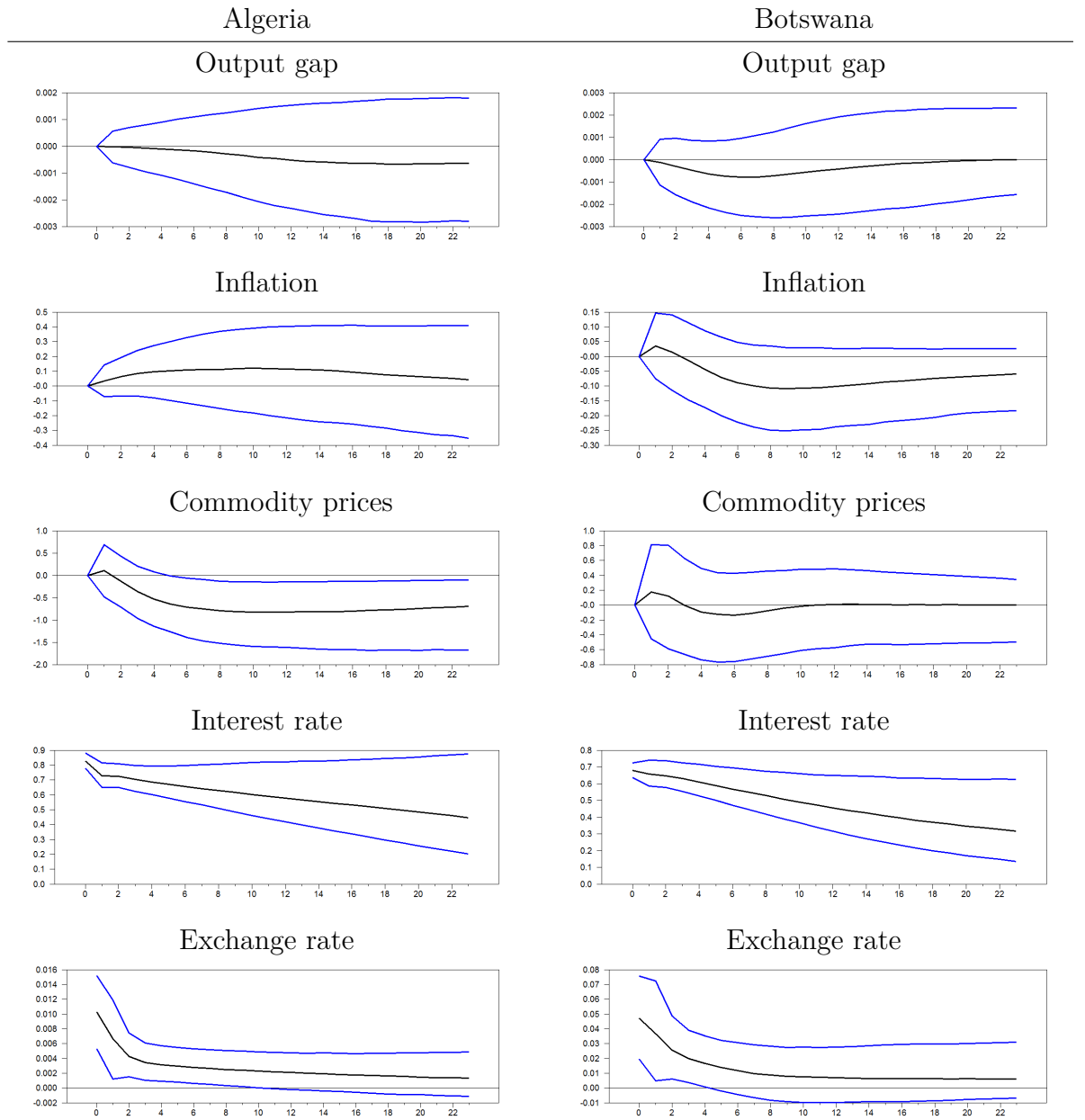


Figure 7.1: Impulse Responses for Algeria and Botswana of the BVAR to one SD Monetary Policy Shock.

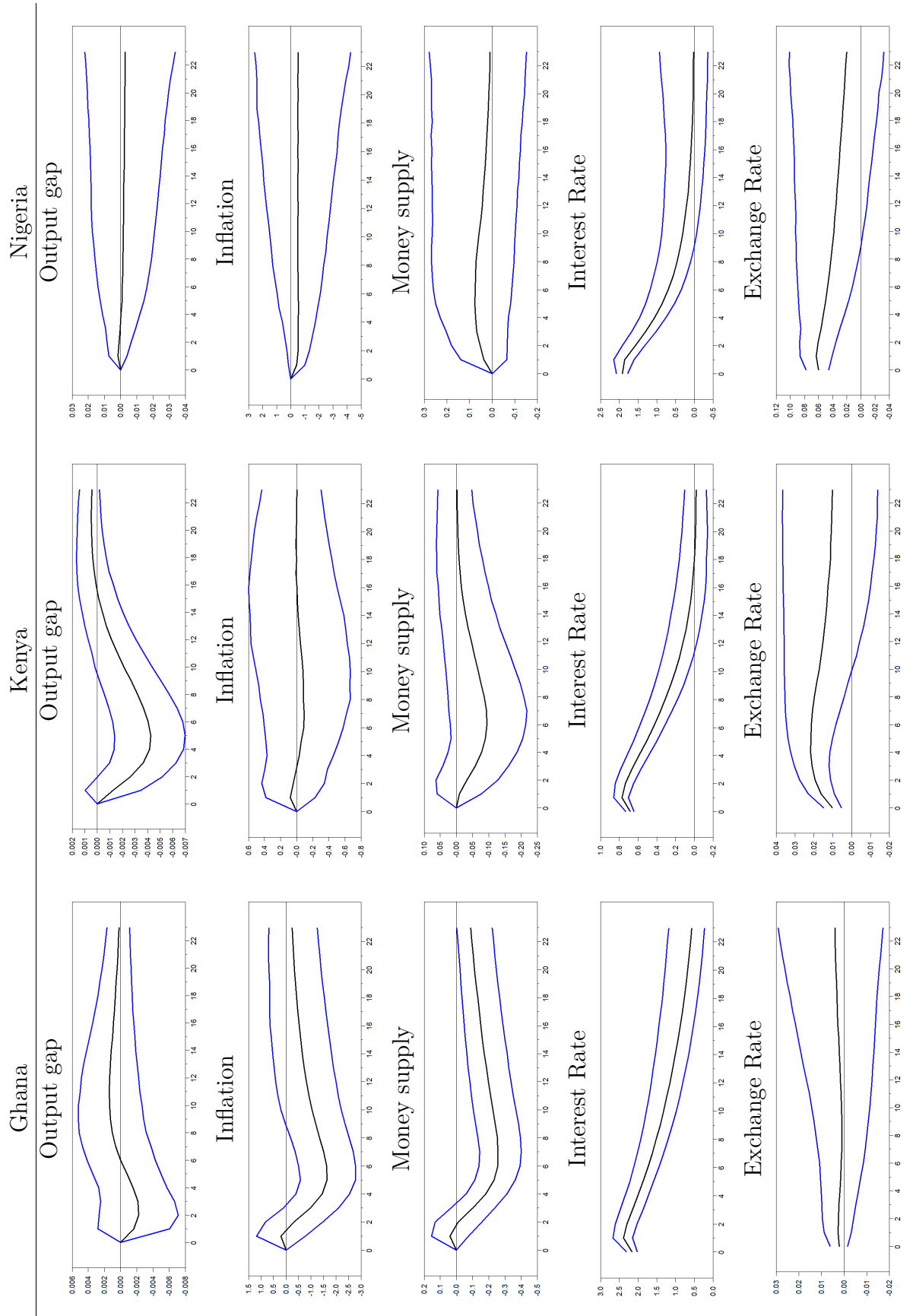


Figure 7.2: Impulse Responses for Ghana, Kenya and Nigeria of the BVAR to one SD Monetary Policy Shock.

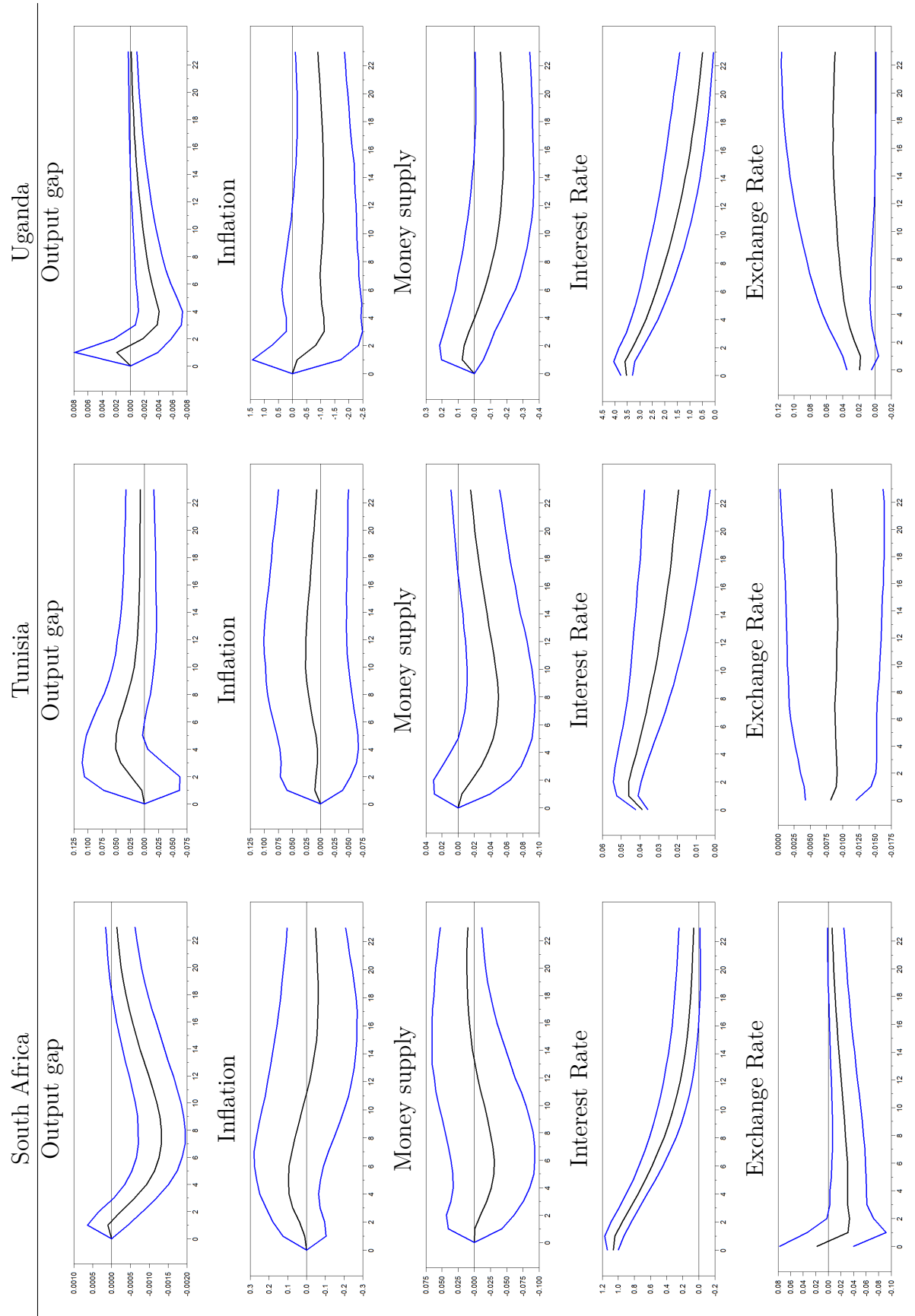


Figure 7.3: Impulse Responses for South Africa, Tunisia and Uganda of the BVAR to one SD Monetary Policy Shock.

7.7 Conclusion

The main purpose of this chapter was to study the problem of informativeness in monetary policy using the BVAR approach for the sample of African economies, over the period 1980:01 to 2012:04. This aim was to characterise the prior belief of monetary policy regarding expectations to macroeconomic shocks, where parameters are treated as random variables that combines information from the sampling data. The output gap falls in response to an interest rate shock.

The findings from this chapter reveals that the magnitude of the interest rate increase with regard to monetary policy in the BVAR is larger on impact than the exchange rate for evaluating the monetary policy transmission mechanism for the sample of African economies. The increase in the interest rate is lowest for Tunisia, perhaps due to the fact that monetary policy has previously targeted the rate of growth of the money supply and therefore the interest rate plays a less important role in the monetary policy framework. For Uganda, the magnitude of a positive interest rate shock has more significant impact. This is to account for the high inflation persistence experienced by the Ugandan economy over recent years, due to the inflow of excess liquidity (Saxegaard, 2006).

The conclusions drawn from this chapter are as follows. Firstly, the impact of the “price puzzle” is absent in the BVAR as compared to the SVAR. This may be due to the fact that the Bayesian analysis combines prior information with the sampling information which is contained in the data. As a result, it provides better estimates of the dynamic impact of the monetary policy transmission mechanism to the economy. These results are consistent with the study of Giannone and Reichlin (2006); Koop (2010) and Banbura et al (2010) using the BVAR approach. Secondly, the results indicate that there is less evidence of a liquidity puzzle, which is the finding that a rise in interest rate causes highly significant increase in the money supply.

Chapter 8

Conclusions and Policy Recommendations

8.1 Introduction

This thesis has sought to examine dynamic relationships between inflation and monetary policy in a sample of African economies where limited research has been conducted thus far and applies the VAR framework for three distinctive methodologies over the period 1980:01 to 2012:04. The summary of the literature review suggests use of different transmission mechanisms with regard to inflation dynamics. The research focuses on three main theoretical frameworks, examining the structural decomposition of the economy using the NKM, where shocks are as a result of dynamic impact of shock from aggregate supply, aggregate demand, money demand, money supply, commodity prices and the exchange rate shocks. The research uses inflation thresholds to explain the relevancy of central bank credibility and monetary policy reactions to high and low levels of inflation. The last theoretical link characterises the uncertainty in monetary policy which considers the central bank's prior belief about shocks to structural macroeconomic variables in the economy.

The empirical literature shows that most studies on inflation and monetary policy have been conducted on the U.S and developed economies, with limited research being done on developing and Emerging market economies and especially, the African economies. The empirical contributions of the thesis to the literature were to investigate the transmission mechanism of monetary policy shocks to the economy, to examine asymmetric effects of monetary policy shocks which are caused by inflation thresholds and lastly, to explore the performance of the monetary policy transmission mechanism in the sample of African economies.

The sample period coincides with a host of significant institutional policies such as central bank independence and macroeconomic reforms aimed at stabilising the structures of the African economies. The outline of the chapter proceeds as follows. Following the introduction, section 8.2 summarises major findings and conclusions while section 8.3 pinpoints the contributions of the thesis to the literature. Sections 8.4 discusses policy implications and lastly, section 8.5 offers an avenue for further research.

8.2 Summary and Conclusions

Chapter 4 examines data and testing for stationarity. The results obtained indicate that the KPSS and LS tests perform better than the ADF and PP tests in the presence of stationarity and structural breaks with a unit root. While the ADF and PP tests find a unit root for inflation, this is insignificant with the KPSS and LS tests. The reason being that the latter tests do not suffer from spurious rejections and bias, which is common with the unit root tests. The money supply is significant in levels using the KPSS test. These results also show that the output gap is stationary in levels for the sampled economies, while mixed findings are obtained for the interest rate and the exchange rates. This is perhaps due to the fact that these tests do not consider the time-lag between monetary policy actions and preferences in response to changes in macroeconomic variables.

The chapter offers a contribution in modelling structural breaks within unit root tests in monetary policy. Structural break points were endogenously determined from the data. This is to eliminate bias that may arise in an attempt to exogenously determine the break dates. The results obtained show that the break dates correspond with the host of institutional frameworks (such as SAP and HIPC initiatives) and macroeconomic reforms which occurred in the mid-eighties and nineties. The results obtained are robust to the finding that the two breaks minimum LM test exhibits more power and less sample size distortion than the one break point test in the presence of structural breaks in unit root.

Chapter 5 investigates the effectiveness of monetary policy in the sample of African economies, using the SVAR approach. The results from this method are consistent with evidence from the literature on developed economies that monetary policy influences the determination of fluctuations in the output gap and inflation through changes in the interest rate. In terms of the variance decompositions, the results indicate that own shocks to the output gap explain a higher proportion of its variance than the other shocks in the system. This means that

supply shocks are the most dominant determinants of the output gap in the sample of African economies, which is consistent with evidence from the literature review. With the exception of Kenya, monetary policy shocks are not the dominant forces on output gap fluctuations in the sample economies. For Kenya, this may imply that the impact of monetary policy shocks on the output gap are dominant due to negative supply shocks, such as droughts that has affected the Kenyan economy in the recent past.

A key finding of this chapter suggests that when monetary policy shocks are identified through changes in the money supply, the impact on the output gap is stronger than those identified through changes in the exchange rate and the short-term nominal interest rate. In particular, the money supply shocks are the dominant force for fluctuations to the output gap in Nigeria and South Africa, accounting for 12-28% of its variance after eight quarters to the shock from monetary policy. This is partly explained by the relatively large size of these economies and functionally developed financial markets. The overall results show that supply shocks account for the relative contribution of inflation in Algeria, Ghana, Kenya and Tunisia. Innovations in the money supply accounted for the relative significance of inflation in Nigeria, South Africa and Uganda, while commodity price shocks partly explained shocks to inflation in Botswana. It is not surprising that the main contribution of shocks to inflation in Botswana are caused by commodity prices, given that the Botswanan economy is dependent on the sales of its diamonds, which has brought stability in the economy over the past four decades. For Uganda, money supply shocks account for a large part of the variance in inflation given that monetary policy has previously targeted the growth rate of the money supply and ITL was recently introduced by the BoU in 2011.

In Chapter 6, non-linearity between inflation and monetary policy was examined, where inflation regimes are endogenously determined. The chapter offers two theoretical arguments to underpin the reason why inflation is used as a propagator of the asymmetric adjustment to monetary policy. These include a narrative and intuitive approach to central bank credibility. There, we assume two types of monetary policy makers; a conventional and an opportunistic monetary policy maker. Both types of monetary policy maker take inflation as their main monetary policy objective, but differ slightly on their reaction to inflation. The conventional monetary policy maker reacts gradually and not very persistently when inflation is too high and optimal monetary policy is inflation targeting. By being risk averse, the policy maker minimizes the cost of any deliberate monetary policy action by observing inflationary expectations. On the other hand, the op-

opportunistic monetary policy maker's optimal monetary policy is disinflation, but also considers output stabilization when inflation is low (Orphanides and Wilcox, 2002). Under the opportunistic approach, the central bank undertakes deliberate monetary policy actions when inflation exceeds its threshold level. The chapter uses the Phillips curve as a theoretical basis to show how non-linearity in inflation may have caused changes in the dynamic relationship between inflation and the monetary policy reaction function.

The results reveal strong asymmetric response in the monetary policy interest rate when inflation exceeds its threshold value, which is particularly evident in the high inflation regime. The response of monetary policy shows that the magnitude of the interest rate increase is much stronger in the high inflation regime than in the low inflation regime. This reveals asymmetric effects in monetary policy to bring down inflation to low levels. The output gap falls in response to a positive monetary policy shock that increases the interest rate in response to inflationary expectations. These results are consistent with evidence in the literature; see Mandler (2012) and Balke (2000). It emerges from the empirical results that in the low inflation regime, economic agents slowly adjust their expectations about inflation and inflation is insignificant. Through the multiplier effect of investment in response to lower interest rate, there is a strong initial response of the output gap in the contemporaneous period to the shock to monetary policy. In the medium term, inflation rises along with its determinants such as commodity prices. This eventually puts the economy into the high inflation state. The analysis suggests that monetary policy in the African economies is regime-dependent, characterized by changes in inflation. The output gap declines temporarily, on average in the high inflation regime due to a strong effect from monetary policy shocks. The conclusion drawn from this study reveals that asymmetry arises from the interaction between inflation and monetary policy shocks.

Chapter 7 explores the monetary policy transmission mechanism in the African economies, using the BVAR approach. The uncertainty in monetary policy is captured by hyper-parameters, which represents the general belief about the series of macroeconomic variables in the model. The chapter uses the Litterman prior as a method of avoiding the over fitting problem which is associated with unrestricted VAR models. This result suggests that the variance of monetary policy increases when monetary policy is accommodative by allowing for a high degree of uncertainty in its monetary policy framework. In particular, when policy makers lower the interest rate and shocks to the macroeconomic variables are persistent, the policy ineffectiveness by the central bank, due to a high degree of uncertainty

not being accounted for, by the monetary authority. The IRF are forecast graphs of the dynamic response of monetary policy to shocks from the macroeconomic variables. The results on the real domestic variables which are the output gap, inflation and the money supply are consistent with evidence from the literature that a contractionary monetary policy shock that increases the short-term interest rate is followed by a fall in the output gap, inflation and the money supply, for the period contemporaneous to the shock from monetary policy.

The findings from this chapter reveals that although the exchange rate is positive, the magnitude of the rise in interest rate due to the monetary policy in the BVAR is larger on impact than the exchange rate, in terms of analysing changes in the performance of the monetary policy transmission mechanism for this sample of African economies. The overall results indicate that the impact of the “price and liquidity puzzles” is insignificant in the BVAR as compared to the SVAR. This may be due to the fact that the Bayesian analysis combines prior information with the sampling information which is contained in the data. As a result, it provides better estimates of the dynamic impact of monetary policy shocks to the economy. These results are consistent with similar studies in the literature as in Giannone and Reichlin (2006), Koop (2010) and Banbura et al (2010) using the BVAR approach. The next section highlights the main contributions of the thesis to the literature.

8.3 Contributions

This thesis studies the effects of inflation dynamics and monetary policy for Algeria, Botswana, Ghana, Kenya, Nigeria, South Africa, Tunisia and Uganda. The novelty of this thesis can be summarised into the following contributions. In Chapter 3, the thesis uses a narrative approach to explaining the exchange rate and monetary policy frameworks in this sample of African economies. We found that the exchange rate arrangements of the sampled economies reflects the institutional frameworks (SAP and stabilization programmes) initiated in the mid 1980’s to improve macroeconomic policies and domestic competitiveness. The results reveal that the data captures the stylized facts of an evolution in monetary policy in these economies as attempts are being made in reducing inflation and deviations from output growth. The thesis established that the adoption of inflation targeting has reduced the variance of inflation in the African economies which is indicative of a strong monetary policy framework.

As an original contribution to the thesis, in Chapter 4, we have provided a

statistical approach for interpolating low frequency series to high frequency data with a high degree of precision. This has been tested to produce the same trend for generating monthly data from annual data series (although monthly data has not been used in this thesis). The use of high frequency data in this study was to enable timely policy interventions. A major contribution in Chapter 4 is to account for structural breaks in the unit root tests. This was accomplished by incorporating the LS minimum LM test, which is robust to the Lumsdaine and Papell (1997) test for detecting multiple structural breaks. The results found are that the break dates coincide with a host of macroeconomic reforms and stabilisation policies which implies a common trend in the evolution of monetary policy shocks for the sample of African economies.

Chapter 5 contributes to our understanding of monetary policy effectiveness of the African economies, by looking at the monetary policy transmission mechanism. Monetary policy is estimated by assuming that shocks are the dynamic effects of the aggregate supply, the aggregate demand, money demand, money supply, exchange rate shock and commodity prices. A key finding of our results is that an interest rate shock on average explain a higher proportion of the variance in the output gap than the exchange rate. This shows a shift in monetary policy focus away from exchange rate management to interest rate targeting as the African economies have become more market oriented. There is new evidence to suggest that the transmission mechanism of monetary policy shocks is not affected by the ordering of the variables but rather based on the theoretical framework underlying the structures of these economies. This suggests the relevancy of the NKM in explaining the dynamics of inflation and monetary policy in this sample of African economies.

In order to determine the asymmetric relationship between inflation and monetary policy macroeconomic variables, we have extended the residual¹ based test to allow for other types of asymmetry. Chapter 6 fills an important gap in the literature to determine the optimal inflation rate for the selected countries by estimating two variants of the inflation threshold models. These include a univariate and a multivariate threshold model allowing for the dynamic interaction between inflation and monetary policy. The research strategy involved testing for thresholds and selecting and estimating a TVAR model, for the sample of African economies. The results reveal that after allowing for the dynamic interaction between inflation and monetary policy variables, the estimated inflation thresholds

¹This involves a non-parametric test, based on the assumption that the form of non-linearity of inflation is unknown, but found evidence in support of non-linearity.

are more consistent with the inflation targets of the African economies than those estimated from the single equation inflation threshold model.

Finally, the contribution of chapter 7 to the literature was to study the problem of informativeness in monetary policy using the BVAR approach for the sample of African economies, over the period 1980:01 to 2012:04, corresponding to 33 years of quarterly observations. This aim was to characterise the prior belief of monetary policy about expectations to macroeconomic shocks, where parameters are treated as random variables that combine information from the sampling data. Impulse responses for policy analysis were derived which represents the probability that the actual distribution of the economy lies within percentiles of the posterior distribution and they are estimated using the Gibbs sampler.

Table 8.1 through 8.3 presents a summary of results comparing all three VAR methods. These results are similar in the sense that the output gap falls following an interest rate shock for this sample of the African economies, with no further evidence about the liquidity puzzle from the BVAR model. The results also show that the price puzzle is negligible using the BVAR approach with the exception of Algeria and Tunisia, where inflation persists after the shock to monetary policy. This is because Algeria and Tunisia are non-inflation targeting emerging economies within the sample of the African economies considered. Their central banks have targeted the exchange rate and the growth rate in the money supply respectively, which is consistent with the results obtained in Chapter 3 of the monetary policy regimes. All three methods are consistent with the finding that a positive monetary policy shocks is manifested by an increase in the exchange rate with the exception of South Africa and Tunisia, where the exchange rate appreciates following the shock to monetary policy. We offer two arguments that may help explain the reason why the exchange rate is positive following the shock from monetary policy. Firstly, since most of the African economies are commodity dependent economies, the depreciation of the exchange rates has acted as a mechanism for promoting export diversification, in terms of increasing exports (to stimulate the economy) aimed at improving the current accounts balance. Secondly, the results also show weak exchange rate channel of the monetary policy transmission mechanism in the African economies, given that higher import prices following the depreciation of the exchange rate causes inflation.

Table 8.1: Summary of Results for the Output gap and Inflation

Response of the Output gap					Response of Inflation			
Country	SVAR	TVAR _L	TVAR _H	BVAR	SVAR	TVAR _L	TVAR _H	BVAR
Algeria	↓	↑	↓	↓	+	—	+	+
Botswana	↓	↑	↓	↓	—	—	+	—
Ghana	↓	↑	↓	↓	—	+	—	—
Kenya	↓	↑	↑	↓	+	—	+	—
Nigeria	↓	~	↓	↓	+	~	+	—
South Africa	↓	↑	↓	↓	+	+	+	—
Tunisia	↓	↑	↓	↓	+	—	—	+
Uganda	↓	↓	↓	↓	—	—	—	—

Note: ↓ = the output gap falls, ↑ = the output gap increases, ~ = no change.
 — = inflation is negative and + = inflation is positive.

Table 8.2: Summary of Results for Commodity Prices and Money Supply

Response of Commodity Prices					Response of Money Supply			
Country	SVAR	TVAR _L	TVAR _H	BVAR	SVAR	TVAR _L	TVAR _H	BVAR
Algeria	×	×	+	×				
Botswana	×	×	×	×				
Ghana					—	—	—	—
Kenya					+	—	—	—
Nigeria					—	~	—	+
South Africa					+	—	+	—
Tunisia					—	—	—	—
Uganda					—	—	—	—

Note: × = No evidence of a commodity price puzzle, + = commodity price is positive,
 — = money supply is negative, + = money supply is positive and ~ = no change.

Table 8.3: Summary of Results for the Interest rate and the Exchange rate

Response of the Interest Rate					Response of the Exchange Rate			
Country	SVAR	TVAR _L	TVAR _H	BVAR	SVAR	TVAR _L	TVAR _H	BVAR
Algeria	+	+	+	+	+	+	+	+
Botswana	+	+	+	+	+	+	—	+
Ghana	+	+	+	+	+	+	+	+
Kenya	+	+	+	+	+	+	—	+
Nigeria	+	~	+	+	+	~	+	+
South Africa	+	+	+	+	—	—	—	—
Tunisia	+	+	+	+	—	—	—	—
Uganda	+	+	+	+	+	—	+	+

Note: + = the interest rate is positive, + = the exchange rate is positive (depreciates)
 — = the exchange rate is negative (appreciates) and ~ = no change.

8.4 Policy Implications of the Research

The findings from this research have relevant policy implications for the African economies whose monetary policy objectives are dependent on price stability. This section discusses policy implications derived from the empirical frameworks used in this thesis. From this study, it was observed that the monetary policy conditions could be used as a potential area that could explain the levels of development and general performance of the wider economy. The following policy lessons can be drawn from this research. The effects of monetary policy through changes in the interest rate are manifested by a highly significant reduction in the output gap. The response of the output gap fall following an interest rate shock is similar across countries, which may suggest a common trend in movements in the business cycle across Africa.

The thesis finds that monetary policy shocks are not the dominant sources of the output gap fluctuations but shocks to aggregate supply. The determinants of inflation in Algeria, Ghana, Kenya and Tunisia are aggregate supply shocks. Innovations in the money supply account for the relative significance of inflation in Nigeria, South Africa and Uganda, while commodity price shocks partly explained shocks to inflation in Botswana.

Monetary policy in the African economies has become more pragmatic through the use of market based instruments (such as the interest rate) in conducting the

monetary policy. The thesis shows that monetary policy shocks on average explain a more significant proportion of the variance in the output gap than the exchange rate. This shows a shift in monetary policy focus away from exchange rate management to interest rate targeting as the African economies have become more market oriented, this may help explain why inflation has been more stable recently.

Another major policy implication derived from the thesis is that the asymmetry in monetary policy arises from the dynamic interaction between inflation and the macroeconomic variables. This means that the monetary policy target of inflation depends on the dynamics of other macroeconomic variables in the economy and not just shocks to inflation alone. It is imperative that subsequent inflation targeting frameworks will stabilize the economy and achieve monetary policy objectives for the African economies, and the use of interest rate management should be continued.

Although inflation targeting was recently introduced in the early 2000's, the study finds that the interest rate were important during the periods of monetary targeting and the exchange rate arrangements. This shows that interest rates were used even though inflation targeting was not officially announced, which is a form of hybrid inflation targeting framework. This is currently the case with the CBK, where even though inflation targeting has not been officially introduced, the interest rate is used as a complement for the growth rate in the money supply and the exchange rate. In the monetary targeting economies such as Nigeria and Tunisia, the interest rate is used as an anchor for the growth rate in the money supply.

Most of the African economies use interest rate to influence changes in the real economy, but maintaining stability of the exchange rate is important especially in the higher phase of asymmetric relationships in monetary policy with respect to the inflation thresholds. Given that the exchange rate plays an important role in the monetary policy frameworks of the African economies, requires the central banks to tighten monetary policy when there is concern that depreciating exchange rates could lead to inflationary tendencies. The policy lesson here is that a tightening of monetary policy through higher interest rate may cause exchange rate appreciation, thereby reducing the cost of imports.

We have also established that monetary policy in the African economies is regime-dependent, characterized by changes in inflation such that the authorities

strongly implement policy changes when inflation goes beyond a certain threshold. This may be due to the time-lag between monetary policy actions and changes in macroeconomics variables.

The thesis recommends that consideration of the prior belief of monetary policy should be taken into account based on information set when conducting monetary policy. Results show that monetary policy has stronger effects on the economy when the uncertainty of the central bank reduces and the shocks to macroeconomic variables are not very persistent.

The overall novelty of the thesis is that some African economies are adopting inflation targeting policies instead of exchange rate management. This shows that the exchange rate is not a target on itself, but it is used as a nominal anchor for the interest rate in conducting the monetary policy. Therefore, monetary policy works through interest rate and the monetary authorities have implications on how to smooth interest rate.

Unlike in the early 1970's when monetary policy was ineffective and still more of an "Art" by relying on selective control mechanisms which were credit ceilings, monetary policy in the African economies has now become a "new science" which emphasises inflation targeting, maintaining output growth and the stability of the exchange rate. To achieve the monetary policy target of controlling inflation, central banks need to have operational independence and mandate to promote price stability, develop greater institutional capacity through credibility and discipline as well as increased transparency by communicating policy decisions for timely interventions and accountability of their operations.

8.5 Limitations and Recommendations for Further Research

This thesis was motivated by the inadequate research on the monetary policy transmission mechanism in the African economies. The research considers the optimal level of inflation that produces an efficient monetary policy framework and how to characterise the belief of monetary policy about expectations to macroeconomic shocks.

The main limitation of the thesis is the inadequacy of data availability as

quarterly data for the money supply and the GDP for Algeria, Ghana, Kenya and Nigeria were interpolated from annual time-series using standard Econometric procedures. However, it has been argued that interpolated data gives high precision and it's easier to predict changes to the economy with it, over aggregated data which often suffers from lag structures and seasonal effects (Casals et al, 2009; Nijman and Palm, 1988 and Lutkepohl, 1984).

Recommendations for further research include: the interaction between fiscal and monetary policy framework to examine the macroeconomic policies of the African economies. Also, these methods can be extended to Emerging market economies which share similar characteristics with the African economies.

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